SHC

IEA SOLAR HEATING & COOLING PROGRAMME

2010

ANNUAL REPORT

Feature Article on

Solar Cooling and Refrigeration

IEA Solar Heating & Cooling Programme

2010 Annual Report

Edited by
Pamela Murphy
SHC Secretariat
IEA Solar Heating and Cooling Programme

www.iea-shc.org

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IEA & SHC Programme

INTERNATIONAL ENERGY AGENCY

When the International Energy Agency (IEA) was founded in 1974, the main objective of its member countries was to reduce dependence on imported oil through the development of alternative energy sources while improving energy efficiency. More recently, concerns such as greenhouse gas emissions and globalization have underlined the need for international co-operation. To support these core issues, the IEA created a legal contract – Implementing Agreement – and a system of standard rules and regulations that would allow interested member and non-member governments to pool resources and research the development and deployment of particular technologies. For more than 30 years, technology collaboration has been a fundamental building block among IEA member and non-member countries in facilitating progress of new or improved energy technologies.

SOLAR HEATING AND COOLING PROGRAMME

The Solar Heating and Cooling (SHC) Programme (also referred to as an Implementing Agreement) was established in 1977 as one of the first programmes in the IEA. The Programme's work is unique in that it is accomplished through the international collaborative effort of experts from Member countries and the European Commission. The benefits of such an approach are numerous, namely, it accelerates the pace of technology development, promotes standardization, enhances national R&D programmes, permits national specialization, and saves time and money.

The Programme is headed by an Executive Committee composed of one representative from each Member country and Sponsor organizations, while the management of the individual projects (Tasks) is the responsibility of project managers (Operating Agents) who are selected by the Executive Committee. Forty-seven Tasks have been initiated to date.

SHC MEMBER COUNTRIES

Australia	European Commission	Mexico	Singapore
Austria	Finland	New Zealand	South Africa
Belgium	France	Netherlands	Spain
Canada	Germany	Norway	Sweden
Denmark	Italy	Portugal	Switzerland
			United States

The Programme's work is augmented through collaboration with other IEA Programmes, such as the Energy Conservation in Buildings and Community Systems Programme, the Photovoltaic Power Systems Programme, and the SolarPACES Programme, as well as solar trade associations in Europe, North America, and Australia.

Our Misson

The SHC mission for 2009-2013 is:

> *To advance international collaborative efforts for solar energy and provide significant added value to national R,D & D, and policy and program initiatives related to the built environment and for agricultural and industrial process heat to reach the goal set in the vision of contributing up to 50% of the low temperature heating and cooling demand by 2030.*

This mission assumes a whole building approach to the application of solar technologies and designs. Based on this mission, the Programme will continue to cooperate with other IEA Implementing Agreements as well as the solar industry to expand the solar market. Through international collaborative activities, the Programme will support market expansion by providing access to reliable information on solar system performance, design guidelines and tools, data, etc. and by developing and integrating advanced solar energy technologies and design strategies for the built environment and for agricultural and industrial process heat applications.

To fulfill this mission, the Programme will direct its results to the design community, the solar manufacturers, and the energy supply and service industries that serve the end-users and building owners.

Our Objectives

The SHC Executive Committee has agreed upon the following objectives and associated strategies to fulfill its mission.

<u>SHC Objective 1</u>
To be the primary source of high quality technical information and analysis on solar heating and cooling technologies, designs and applications.

Strategies

- Assure that technical **information** and **analysis** developed in this Agreement is available and disseminated to the target audiences in useful formats.
- Working through relevant international standards organizations, support the development and harmonization of **standards** necessary for the widespread use of solar designs and technologies in the building, agricultural and industrial sectors.

<u>SHC Objective 2</u>
To contribute to a significant increase in the performance of solar heating and cooling technologies and designs.

Strategies

- Increase **user acceptance** of solar designs and technologies.
- Continue to develop **cost-effective** designs and technologies in collaboration with appropriate intermediary industries.
- Identify and prioritize **R&D needs** for solar heating and cooling that will lead to expanded markets

<u>SHC Objective 3</u>
To enhance cooperation with industry and government on increasing the market share of solar heating and cooling technologies and designs.

Strategies

- Work with appropriate **intermediary industries** and end users to accelerate the market penetration of solar designs and technologies.
- Work with governments to promote and expand **favorable policies** to increase the market share.
- Work towards or support the greater use of solar designs and technologies in **developing countries**.
- Work to address issues regarding building design, aesthetics and architectural value.

SHC Objective 4
To increase the awareness and understanding on the potential and value of solar heating and cooling systems by providing information to decision makers and the public.

Strategies

- **Communicate** the value of solar heating and cooling designs and technologies in publications, conferences, workshops and seminars to the public and relevant stakeholders.
- Provide **analysis** that links solar heating and cooling designs and technologies to energy security concerns, environmental and economic goals.
- **Quantify and publicize** the environmental, economic and climate change benefits of solar heating and cooling and supporting policy measures solar design and technologies in meeting environmental targets and addressing policies and energy, supply security.
- **Review** our products in relation to our objectives – Annual Reports, Solar Update Newsletters, National Programme Review Reports, "*Solar Heating Worldwide: Markets and Contributions to the Energy Supply report.*"
- **Present** the SHC Solar Award annually/bi-annually. **Maintain** the SHC web site.

Chairman's Report

Werner Weiss
AEE INTEC, Austria

It is with great pleasure as the new Chairman of the Solar Heating and Cooling Programme to share with you our achievements of 2010. It was a year of many positive additions and notable progress for this Programme and solar thermal.

On the Programme level, we welcomed South Africa and Singapore to the Implementing Agreement. South Africa quickly jumped into Programme activities by hosting our November Executive Committee. The Executive Committee members are looking forward to working with both countries.

In addition to growing the Programme's membership, the Executive Committee took three significant steps to increase both the visibility of the Programme and of solar thermal:

- Establishment of a SHC Information Center.
- Organization of an international solar heating and cooling conference. The first conference will be held in 2012 and every other year thereafter.
- Contribution to the IEA's Solar Heating and Cooling Roadmap.

On the Task level, another round of exciting new work was initiated to support our strategic focus on market deployment and R&D. This work includes Task 45, after 20 years the SHC Programme will once again focus on district heating but this time with the addition of cooling. Two other Tasks will continue our work in the areas of solar resources and solar renovation, Task 46 on solar resource assessment will address the stringent data requirements of the solar industry and Task 47 on the renovation of non-residential buildings will develop a solid knowledge base and identify key market and policy issues as well as marketing strategies.

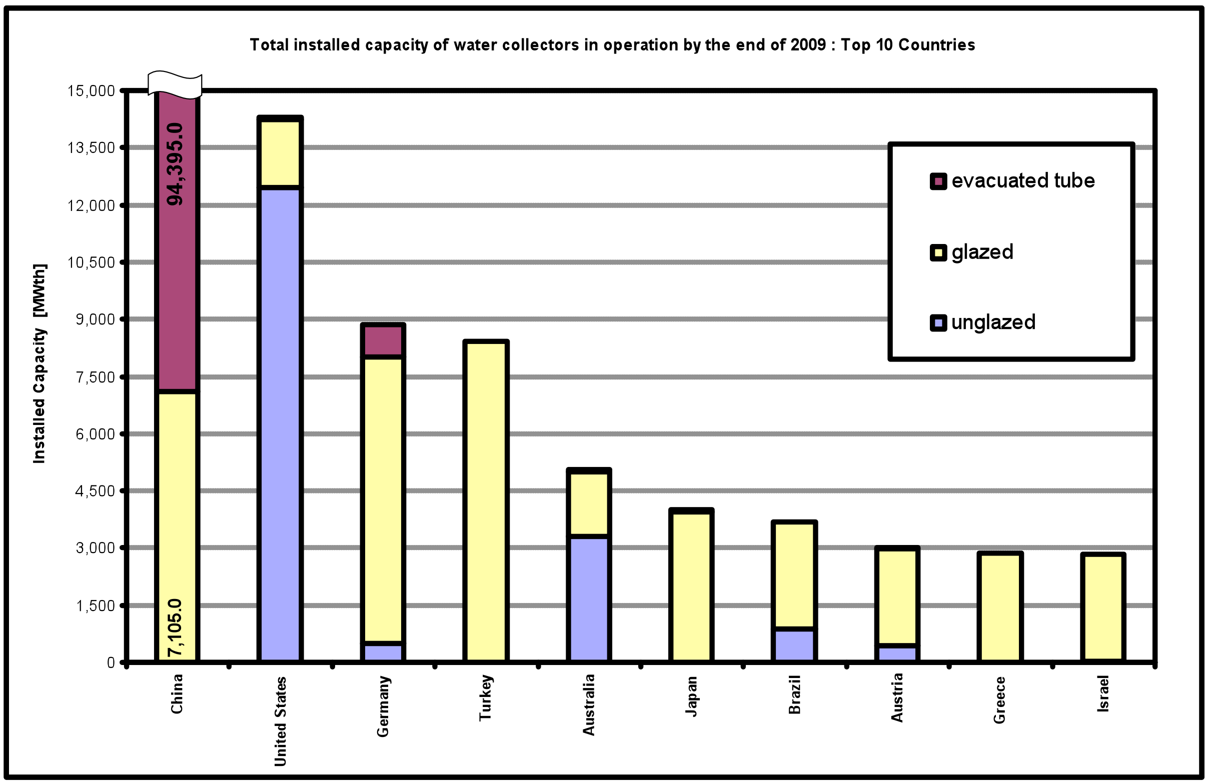
Our new initiates don't stop there. Tasks under development and that will begin in 2011 include solar heat integration in industrial process with an emphasis on reliable, cost effective systems, system optimization and new applications; continued work in the critical area of solar cooling, this time focusing on quality assurance measures; and a new area for the Programme – utility solar heating and cooling programs.

GLOBAL SOLAR STATISTICS

To track the growth of solar thermal, the SHC Programme produces an annual statistics report, *Solar Heat Worldwide: Markets and Contribution to the Energy Supply.* The 9th edition reports that in 2009, solar thermal technologies produced **141,775 GWh** – an oil equivalent of 14.4 million tons and annual avoidance of 46.1 million tons of CO_2 emissions. New installations of water collectors grew 25.3 % compared to 2008 with 90.8% of the growth from the installation of glazed water collectors in China and Europe.

Key findings:

- Total Installed capacity in operation by the end of 2009 was 172.4 GW_{th} (246.2 million square meters):
  - 151.5 GW_{th} flat-plate and evacuated tube collectors
  - 19.7 GW_{th} unglazed plastic collectors
  - 1.2 GW_{th} air collectors
- Global market for evacuated tube collectors grew by 34 % and for flat-plate collectors by 4.4 % compared to 2008.



Source: IEA SHC Programme, Solar Heat Worldwide, 2011 edition

- Market penetration (total installed capacity of water collectors in operation per 1,000 inhabitants) leading countries:
  - Cyprus 554 kW_{th}; Israel 394 kW_{th}; Austria 367 kW_{th}; Barbados 324 kW_{th} and Greece 266 kW_{th}
- 2010 data estimate total capacity in operation will be 196 GW_{th}.

Worldwide, we are just beginning to scratch the surface of the market for solar heating and cooling. However, the annual energy recoverable from solar is more than one thousand times the current world energy use, so there is tremendous growth potential. What is needed in addition to technology innovation, are very dramatic changes in energy policies around the world so that this potential can be tapped in a significant way in the near future.

SHC TASKS

2010 was the start of important work in the area of district heating and cooling and a continuation of our work in the areas of solar resource assessment and building renovation.

- Task 45: Large Solar Heating/Cooling Systems, Seasonal Storages, Heat Pumps *(Lead Country: Denmark)*
- Task 46: Solar Resource Assessment and Forecasting *(Lead Country: United States)*
- Task 47: Renovation of Non-Residential Buildings Towards Sustainable Standards *(Lead Country: Norway)*

And, the proposal of work in the areas of solar heat integration in industrial processes, solar cooling and utility solar heating and cooling programmes.

The year ended with completion of two Tasks.

- Task 36: Solar Resource Knowledge Management *(Lead Country: United States)*
- Task 38: Solar Air-Conditioning and Refrigeration *(Lead Country: Germany)*

SHC SOLAR AWARD

The recipient of the *2010 SHC Solar Award* was Mr. Helmut Jäger, a pioneer in the market development of solar thermal collectors and systems in Germany and throughout Europe. The award was presented at EuroSun 2010 in Graz, Austria.

SHC Solar Award recipient Helmut Jäger and SHC Chairman. Werner Weiss.

The SHC SOLAR AWARD is given to an individual, company, or private/public institution that has shown outstanding leadership or achievements in the field of solar heating and cooling, and that supports the work of the IEA Solar Heating and Cooling Programme.

Mr. Helmut Jäger is the sixth recipient of the SHC SOLAR AWARD. He was selected for his extensive work in the development of innovative solar thermal technologies. In 1988, Mr. Jäger founded Solvis, a thermal solar systems manufacturer. Over the next 20 plus years, Solvis has produced products ranging from stratified solar storage tanks to advanced solar collectors. In 2007, Solvis became a leading producer of absorbers in Europe. Solvis has maintained a commitment to environmental stewardship, and in 2002 opened Europe's largest zero-emission factory.

Recipients of this award include:

- Prof. Collares Pereira, Portugal
- Dr. Volker Wittwer, Germany
- Prof. Jan-Olof Dalenbäck, Sweden
- Prof. William Beckman, USA
- Mr. Torben Esbensen, Denmark

COLLABORATION WITH OTHER IEA PROGRAMMES & INTERNATIONAL ORGANIZATIONS

To support our work, the SHC Programme is collaborating with other IEA Programmes and solar organizations.

Within the IEA

IEA Energy Conservation in Buildings and Community Systems Programme is collaborating in *SHC Task 40: Net Zero Energy Solar Buildings* at a moderate level[1].

IEA Energy Conservation through Energy Storage Programme is collaborating at a joint level[1] in *SHC Task 42: Compact Thermal Energy Storage*. This is the first fully joint Task with Operating Agents from each Programme. The Executive Committees will hold a joint meeting in November 2011 in conjunction with their respective Executive Committee meetings.

IEA Heat Pump Programme is collaborating at a maximum level[1] in *SHC Task 44: Systems Using Solar Thermal Energy in Combination with Heat Pumps.*

IEA Photovoltaic Power Systems Programme is collaborating in *SHC Task 36: Solar Resource Knowledge Management* at a minimum level[1].

IEA SolarPACES Programme is collaborating in *SHC Task 36: Solar Resource Knowledge Management* at a minimum level[1].

Outside the IEA

Solar Industry Associations in Australia, Europe and North America are collaborating with the SHC Programme to increase national and international government agencies and policymakers awareness of solar thermal's potential and to encourage industry to use solar thermal R&D results in new products and services.

To support this collaboration, the *5th SHC/Trade Association* meeting was held June 11, 2010 in conjunction with InterSolar trade fare in Munich, Germany.

International Solar Energy Society (ISES), the Programme once again co-organized EuroSun with ISES/ISES Europe. This year's conference was held in Graz, Austria and SHC ExCo members, Operating Agents and Task experts participated in the organizing committees as well as the conference.

ETP RHC (European Technology Platform on Renewable Heating and Cooling), the SHC Programme, represented by Mr. Lex Bosselaar and Mr. Werner Weiss, continues to serve on the Solar Thermal Panel's Steering Group and the board to support the Platform's objectives.

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[1] As outlined in the SHC Policy & Procedures Handbook

EXECUTIVE COMMITTEE MEETINGS

2010 Meetings
The Executive Committee held two meetings:

- June 21-24 in San Francisco, California, USA
- November 15-18 in Cape Town, South Africa

2011 Meetings
The Executive Committee will hold two meetings:

- June 6-8 in Copenhagen, Denmark
- November 9-11 in Bad Aibling, Germany

Executive Committee members and Operating Agents at the Cape Town meeting.

PROGRAMME PARTICIPATION – WHY JOIN

Participation in the Programme remains strong with 20 Member countries and the European Commission actively involved in the Programme's management and the work of the Tasks. Communication continued with countries that have been invited to join the Programme– Brazil, Chile, China, India, Japan and South Korea. In 2010, the Executive Committee unanimously voted to invite the Ukraine to join the Agreement.

The SHC Programme is unique in that it provides an international platform for collaborative R&D work in solar thermal and solar buildings. The benefits for a country to participate in this Programme are numerous and include:

- Accelerates the pace of technology development through the cross fertilization of ideas and exchange of approaches and technologies.
- Promotes standardization of terminology, methodology and codes & standards.
- Enhances national R&D programs thorough collaborative work.
- Permits national specialization in technology research, development or deployment while maintaining access to information and results from the broader project.
- Saves time and money by sharing the expenses and the work among the international team.
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TO ANOTHER SUCCESSFUL YEAR

I would like to thank Doug McClenahan for leading this Programme over the last four years. Under his Chairmanship, the Programme grew in members, expanded its work and continued to raise public awareness of the potential of solar thermal systems and solar applications in buildings at the local, national and global levels. I look forward as Chairman to carrying on where he left off.

Before closing, I would like to thank our outgoing and welcome our incoming Executive Committee members. In

2010, we said good-bye to Dr. Esther Rojas of Spain, Mr. Ivo Blezer of the Netherlands, Mr. Mattias Törnell of Sweden, and Mr. Robert Hassett of the United States. On behalf of the Committee, I would like to thank them for their dedicated and forward thinking contributions to the Programme. As these members left new members joined us—welcome to Mr. Kian Seng Ang of Singapore, Dr. Thembakazi Mali and Prof. Ernst Uken of South Africa, Dr. María José Jiménez Taboada and Mr. Ricardo Enríquez Miranda of Spain, and Dr. Jörgen Sjödin of Sweden.

Last but not least, I want to thank the vice chairmen Markus Kratz and João A. Farinha Mendes, all members of the Executive Committee, the Operating Agents of the Tasks as well as all experts working in our projects, the SHC Secretariat Pamela Murphy, and the Webmaster Randy Martin. This excellent team makes our Programme exceptional and successful.

Werner Weiss

HOW TO PARTICIPATE

Learn More
Visit our website — www.iea-shc.org — to stay up to date on our Tasks, to find publications, to contact Executive Committee members and project managers (Operating Agents).

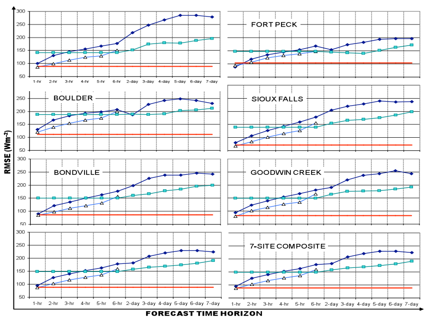
Become A Member
If your ***country is not a SHC Member*** of the Programme, but your government agency or organization is interested in joining the Progamme, please contact the SHC Secretariat for information *(secretariat@iea-shc.org).*

If you represent an ***international industry association or international non-profit organization*** it is possible to become a Sponsor Member, please contact the SHC Secretariat for information *(secretariat@iea-shc.org).*

Become An Expert
If your ***country is a SHC Member*** of then contact the Operating Agent of the Task you are interested in joining and contact the Executive Committee member from your country.

Task Highlights of 2010

TASK 36: SOLAR RESOURCE KNOWLEDGE MANAGEMENT



SUNY/Albany, New York (US) and CANMET Energy (Canada) are evaluating forecasts at high quality ground solar measurement stations in the U.S. and Canada. The U.S. is evaluating satellite-derived cloud motion vectors for short-term (0-6 hour) forecasts, and the National Digital Forecast Database (NDFD) for 1-3-day ahead forecasts at seven Surface Radiation (SURFRAD) solar monitoring stations.

This is a collaborative Task with the IEA Photovoltaic Power Systems Implementing Agreement and SolarPACES Implementing Agreement.

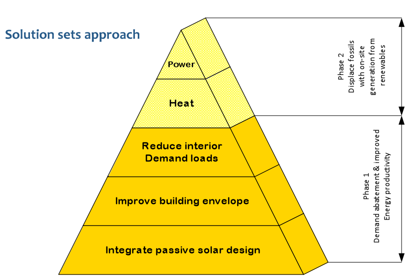
TASK 38: SOLAR AIR CONDITIONING AND REFRIGERATION

A solar cooling system application installed at a winery in Tunisia by the Politecnico di Milano within the European project MEDISCO (MEDiterranean food and agro Industry applications of Solar COoling technologies) was awarded with the Energy Globe Award Tunisia 2009. This installation is part of the monitoring activities within the framework of Task 38 and several Task 38 participants are contributing to the project.

TASK 39: POLYMERIC MATERIALS FOR SOLAR THERMAL APPLICATIONS

Task experts have created a database of architecturally appealing solar thermal systems integrated into buildings. The idea is that pictures say a thousand words so these examples of visually appealing solar systems will encourage homeowners, builders, and architects to use solar. The Architectural Integration of Solar Thermal Energy Systems database can be found at http://www.iea-shc.org/task39/projects/default.aspx

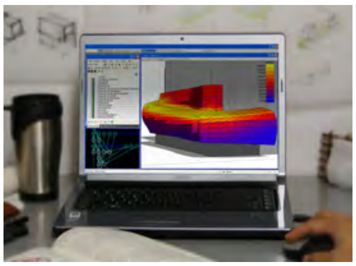
TASK 40: TOWARDS NET ZERO ENERGY SOLAR BUILDINGS



During 2010, 50 projects of NetZEB buildings worldwide were identified for further analysis to come up with solution sets that could inform industry adoption. An analysis matrix of solutions sets categories (passive approaches and envelope, energy efficient systems, and renewable energy) and climate type (cooling dominated, heating dominated, cooling & heating dominated) was developed to document the various projects.

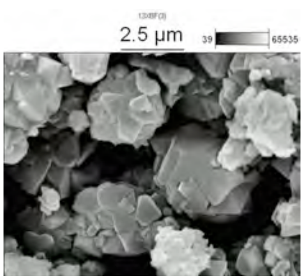
This is a collaborative Task with the IEA Energy Conservation in Buildings and Community Systems Implementing Agreement.

TASK 41: SOLAR ENERGY & ARCHITECTURE



The report *State-of-the-Art of Digital Tools Used by Architects for Solar Design* reviews existing digital tools widely used today. The review covers a total of 56 computer programs. Results show that there is a lack of CAAD tools supporting architectural integration and sizing of active solar systems - feeding an iterative design process. Architects need to "see" and customize the active solar components directly in their building model – and get a rough estimate of the energy contribution simultaneously! The report can be downloaded at http://iea-shc.org/publications/task.aspx?Task=41.

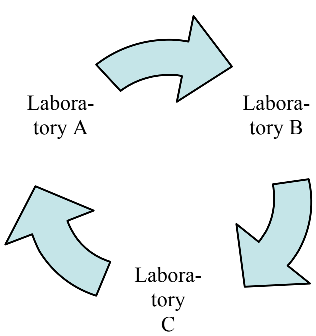
TASK 42: COMPACT THERMAL ENERGY STORAGE



A new type of sorption storage material was developed at the University of Applied Sciences Wildau, Germany in collaboration with the chemical company Chemiewerke Bad Köstritz. They synthesized novel binderless molecular sieves following a new manufacturing strategy for zeolite pellets. Testing results show that the binderless molecular sieves, compared to ordinary materials, are well suited for thermochemical storage and heat transformation due to faster kinetics, higher water adsorption capacities, good hydrothermal stability and improved storage capacities.

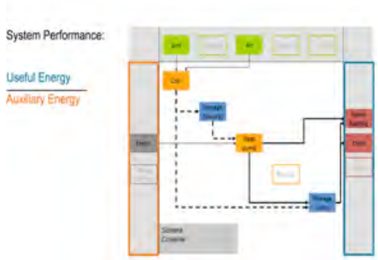
This is a collaborative Task with the IEA Energy Conservation through Energy Storage Implementing Agreement.

TASK 43: RATINGS AND CERTIFICATION PROCEDURES



To confirm the consistency of collector efficiency and durability laboratories in Europe and North America are performing tests. Identical collectors from two single-lot purchases of both flat plate and tubular collectors are being tested by all SRCC accredited North American laboratories, and European laboratories are conducting similar identical lot testing. By testing the same or identical collectors according to EN/ISO and SRCC standards, Task Experts are able to provide an important check on the reproducibility of testing.

TASK 44: SOLAR AND HEAT PUMP SYSTEMS



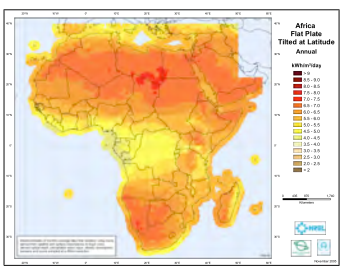
A new way to describe a solar and heat pump configuration was developed in Subtask A. This “square layout” allows an at a glance view of the system. It has other advantages including the depiction of energy fluxes, location of meters and energy performance calculations. A companion description was derived with a letter convention so that the sources and the sinks in the system can be identified with ease.

This is a collaborative Task with the IEA Heat Pump Implementing Agreement.

TASK 45: LARGE SYSTEMS: LARGE SOLAR HEATING/COOLING SYSTEMS, SEASONAL STORAGE, HEAT PUMPS

This Task was approved at the November Executive Committee meeting. The first Experts Meeting will be held in April 2011.

TASK 46: SOLAR RESOURCE ASSESSMENT AND FORECASTING



This Task was approved at the November Executive Committee meeting.

This is a collaborative Task with the IEA Photovoltaic Power Systems Implementing Agreement and SolarPACES Implementing Agreement.

TASK 47: SOLAR RENOVATION OF NON-RESIDENTIAL BUILDINGS

This Task was approved at the November Executive Committee meeting. The first Experts Meeting will be held in March 2011.

Feature Article

Solar Air-Conditioning and Refrigeration

Hans-Martin Henning
Fraunhofer Institute for Solar Energy Systems ISE
SHC Task 38
Operating Agent on behalf of Forschungzentrum Jülich GmbH

INTRODUCTION

The IEA Solar Heating & Cooling Programme has covered the topic of solar cooling for more than 10 years – *Task 25: Solar Assisted Air-Conditioning of Buildings* started in 1999 and was terminated in 2004. *Task 38: Solar Air-Conditioning and Refrigeration* followed in 2006 and had its end in 2010. Significant progress was achieved during this period in both technology development and system implementation. However, solar cooling is still a niche market, although some very large installations have been realized recently. In this article, we provide a brief overview on the development of the technology and present a few specific activities carried out in SHC Task 38.

BRIEF DESCRIPTION OF THE TECHNOLOGY

Although various technologies exist to convert solar heat into cooling there are four dominant technologies being used today:

- *Closed chillers*, which produce chilled water using liquid sorption materials are most common. The dominating material pair is using water as refrigerant and an aqueous solution of LiBr as sorbent. Another pairing being used, even in small cooling capacities, is ammonia as refrigerant and water as sorbent. LiBr-water systems also are available as single-effect machines, which can be operated with temperatures starting at about 75°C, and as double-effect machines with a higher efficiency (higher thermal coefficient of performance $COP_{thermal}$), which require driving temperatures of 130°C and above. While single-effect machines can be operated with non-concentrating solar collectors (high efficient flat plates, evacuated tubes); double-effect machines normally need concentrating solar collectors due to the higher driving temperatures.

- *Closed chillers using solid sorption materials and water as refrigerant* are available from a number of manufacturers. In particular, machines in the small capacity range have been developed in the last years and are entering the market in increasing numbers. Silica gel is used as sorbent in most cases, but also machines using zeolite coatings applied on heat exchanger metal surfaces are now available and show a promising potential for the future.

A completely different category of systems uses salt as sorbent material, which is completely dried during regeneration thereby providing a kind of thermo-chemical storage. Thus a mismatch between availability of driving heat (e.g., coming from solar collectors) and the operation of the cooling system (e.g., during night) can be realized.

- *Open cooling cycles using solid sorption materials* are mainly using rotating wheels with a matrix impregnated with the desiccant material. Various combinations of the desiccant rotor with sensible heat exchangers and evaporative coolers (humidifiers) exist which are adapted to different climatic conditions. New developments aim at an integration of sorption and evaporative cooling in order to operate a cooled sorption process and thereby allowing for higher dehumidification rates compared to the adiabatic process realized in systems with desiccant rotors.

- *Open cooling cycles using liquids as sorption materials* have achieved a status of early market deployment and a number of installations have been realized. Open cooling systems using a liquid desiccant have two main advantages 1) cooling of the sorption process can be realized easier in comparison to systems with solid sorption materials and 2) the concentrated solution can be stored. This provides an attractive way of storage that allows overcoming mismatches between the availability of driving heat and the need of conditioning the ventilation air.

An overview on different systems categorized according to the temperature requirements is given in Table 1.

Driving temperature	Collector type	System type	Typical range $COP_{thermal}$
Low (60-90°C)		***Open cycle:*** direct air treatment	0.6 – 1.2
		Closed cycle: high temperature cooling system (e.g. chilled ceiling)	0.6 – 0.8
Medium (80-110°C)		***Closed cycle:*** chilled water for cooling and dehumidification	0.6 – 0.75
		Closed cycle: refrigeration, air-conditioning with ice storage	0.5 – 0.65
High (130-250°C)		***Closed cycle:*** double-effect system with high overall efficiency	1.0 – 1.3
		Closed cycle: system with high temperature lift (e.g. ice production with air-cooled cooling tower)	0.5 – 0.7

Table 1. Overview of different systems and the corresponding solar collector technology.

ACHIEVEMENTS AND STATUS OF SYSTEM DEVELOPMENT

Systems may be characterized by their size (e.g., rated cooling capacity). However, from a market point of view it is more important to distinguish between pre-engineered systems, which are standardized packages of components and typically used in small residential or commercial buildings, and custom-made systems, which are designed for a specific building.

Small Scale Pre-Engineered Systems

A major achievement in the last years is the development of small capacity water chillers. Ten years ago, the smallest thermally driven chiller available on the market had a capacity of 35 kW and only one manufacturer existed. Today, at least five companies are producing small capacity systems for residential or small commercial applications starting at a rated cooling capacity of about 8 kW. The main bottleneck for a broader application of these systems in combination with solar thermal collectors is – besides the higher initial cost in comparison to conventional technology – the lack of pre-engineered package solutions. It is obvious that these systems only have a chance for broad implementation if the effort for planning, assembly and installation is minimized. Much work has been to achieve such complete package solutions, but there is still a significant way to go towards standardization and real pre-engineering. Nevertheless, one of the great achievements of SHC Task 38 was that a number of installations achieved significant primary energy savings compared to standard technology. For example, an overall electric $COP_{electric}$ of up to 8 for a complete summer month was measured for the best working systems. A $COP_{electric}$-value of 8 means that 8 units of useful cooling were produced with 1 unit of electricity needed for pumps, cooling tower and other auxiliary equipment (see
Figure 1).

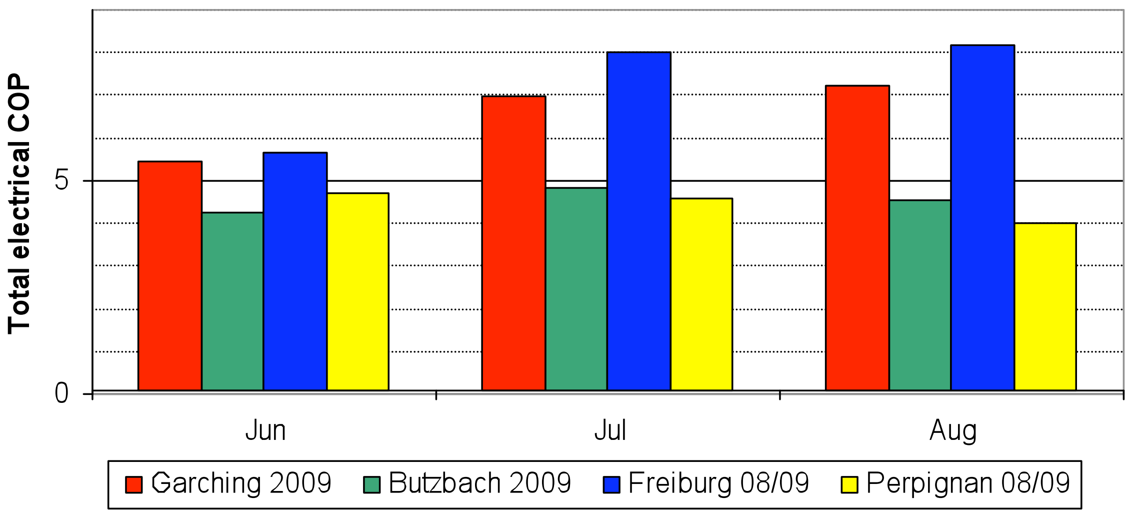


Figure 1. Monthly average $COP_{electric}$ values of four installations monitored in SHC Task 38.

Large Scale Custom-Made Systems

For large commercial buildings and industrial applications each system needs to be adjusted to the particular needs and conditions. Therefore, the development of package solutions is not possible. Nevertheless, standardization is required when it comes to the process of planning and installing.

Tools are needed to evaluate the feasibility of using solar driven cooling in an early phase of a project to minimize the effort and cost. An example of such a tool is the "*Check-list Method for the Selection and the Success in the Integration of a Solar Cooling System in Buildings*" which is available on the website of the company TECSOL SA http://www.tecsol.fr/checklist. It was developed based on the feedback of various solar cooling experiences gained within the framework of SHC Task 38. The method and tool is designed to support the evaluation of the potential of using solar cooling technology in the early phase of a project. Thus all important aspects are considered—technical boundary conditions, financial aspects, questions related to building space and areas for installation of solar collector systems and issues of knowledge and interest of the involved stakeholders. At the end, the check-list method gives a hint on the feasibility of the particular project.

One of the challenges in designing solar heating and cooling systems is the large variety of possible technical solutions and combinations of putting together the main components (solar collectors, secondary heat sources, storages, cooling equipment, etc.). An activity in SHC Task 38 focused on a systematic classification of possible systems and resulted in a methodology to provide an overview of the various solutions and "generic system schemes" representing standardized solar cooling systems and to facilitate the comparison of system concepts suggested by manufacturers and professionals in the field.

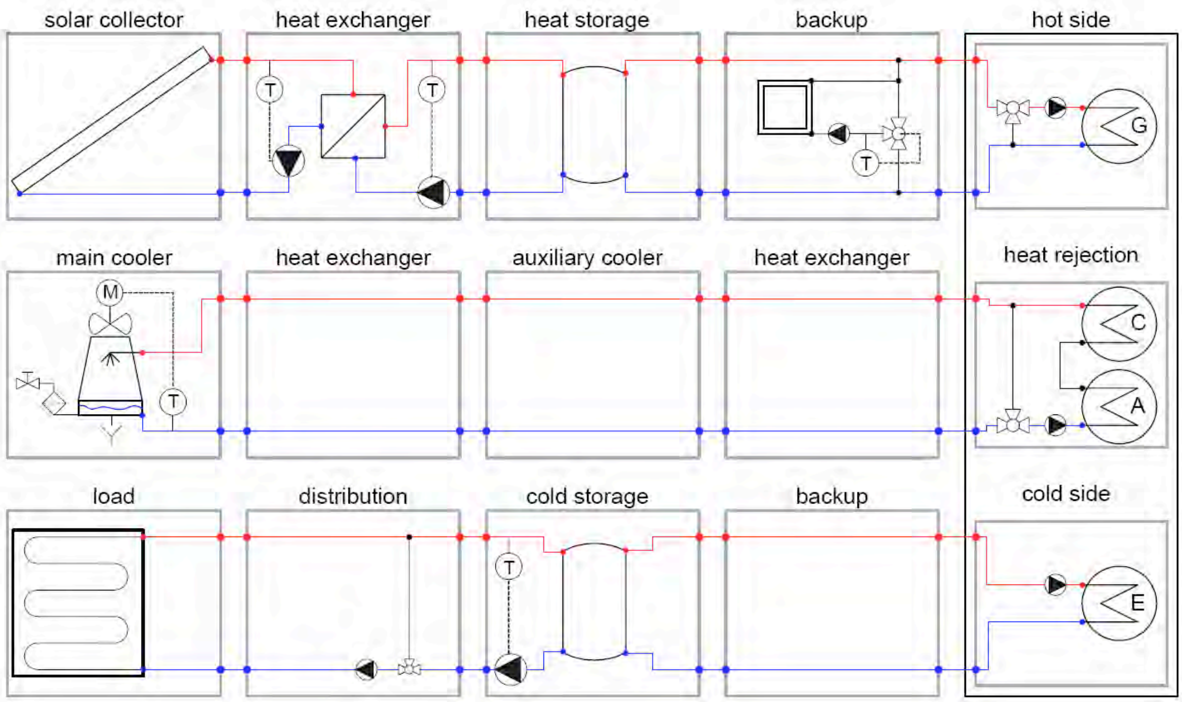


Figure 2. Example of a solar heating and cooling system presented using the generic system scheme.

Another significant achievement in the field of large systems is the installation of a number of pilot systems using concentrating solar collectors. These collectors concentrate the direct sunlight on a linear absorber either using parabolic troughs or Fresnel mirrors. By reaching temperatures of 130°C up to 250°C chillers can operate either with an increased efficiency (thermal coefficient of performance $COP_{thermal}$) compared to single-effect systems or achieve a high temperature lift (see last line of Table 1). A high temperature lift is important if low temperatures on the cold side are to be achieved (e.g., for ice production) and high temperatures have to be used for heat rejection (e.g., operation of a dry cooling tower due to shortage of fresh water or other reasons). This technology opens the market for solar cooling in industrial and commercial applications in countries with warm and sunny climates, such as in southern Mediterranean countries.

Recently a number of very large solar cooling installations have been realized in various countries and applications. Most of these systems were built without major subsidies or incentives demonstrating that an interest on the customer side exists. However, still only very few companies are able to fulfil the needs of this market because not only strong skills in planning and installation are required, but also skills in financial management.

EXAMPLES OF INSTALLATIONS

The following three installations show the wide range of technologies and applications.

Solar Assisted Cooling with Ammonia-Water Chiller and Fresnel Collector

Within the project MEDISCO (MEDiterranean Food and Agro Industry Applications of Solar Cooling Technologies), funded by the European Union, a solar assisted cooling system has been installed at the winery of Domain Neferis in Tunisia. The installed system consists of 88 m² of a new type of concentrating collector, which is the Fresnel collector produced by the company PSE GmbH (Germany). Pressurized water is used as a thermal fluid in the primary solar loop to handle temperatures up to 180°C. The collector field delivers the driving thermal energy to the ammonia-water absorption chiller, which has a cooling capacity of 12.8 kW and was produced by the company ROBUR (Italy). A 3,000 litre water-glycol cold storage was installed to deal with the variation between cold production and consumption in the plant. The installation at the winery of Domain Neferis is one of the 12 demonstration projects within the monitoring work of SHC Task 38. In 2009, the project was awarded the National ENERGY GLOBE Award for Tunisia.

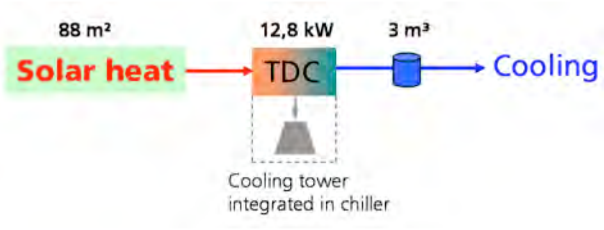


Figure 3. Solar cooling installation at the winery in Tunisia. In front: the Fresnel collector; the cooling of the wine storage tanks, shown in the background, is supported by the chiller, connected to the Fresnel collector.

Solar Assisted Air-Conditioning at FESTO AG Company KG

FESTO AG & Company KG in Esslingen-Berkheim, Germany uses solar assisted air-conditioning in an adsorption chiller plant with 1.05 MW of installed chilling capacity. The chillers were installed in 2001 for air-conditioning the company's new Technology Center and then in 2007 the solar thermal collector system was installed as part of the German Solarthermie 2000plus funding scheme. Figure 4 shows a sketch of the system and the installation site at FESTO. Adsorption chiller technology was chosen because the waste heat from the company's production facility is available at temperatures of approximately 70°C. Originally, the driving heat for the chillers was waste heat and heat from gas boilers. With the addition of 1,218 m² of solar thermal vacuum tube collectors, three sources are supplying heat to the air-conditioning system of the Technology Center. The three chillers, supplied by Mayekawa, each have a capacity of 350 kW capacity. One of the three closed wet cooling towers can be operated in a free cooling mode at low ambient temperatures.

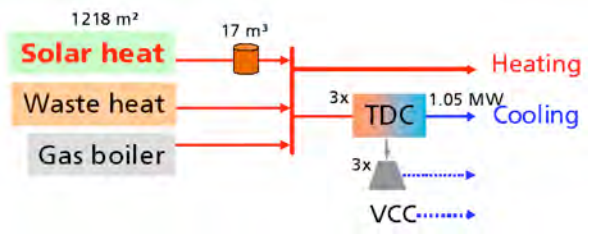


Figure 4. Sketch of the system and aerial view of the plant in Esslingen. FESTO's Technology Center comprises the three large office buildings in the foreground. (*source: FESTO AG & Co. KG*).

Solar Assisted Desiccant Cooling System for Humid Climatic Conditions

At the Department of Energy and Environment Research (DREAM) of the University of Palermo in Italy, a solar assisted DEC system has been installed to air-condition laboratory rooms. The system configuration was specifically adapted for the hot and humid climate in Palermo. It consists of a conventional solid-desiccant unit combined with a vapour compression chiller, which offers the option of pre-dehumidification and additional supply air cooling. The driving heat for the desiccant unit is provided by a field of 22.5 m² flat plate collectors and an auxiliary gas boiler is available for winter. The air-handling unit provides a flow rate of 1500 m³/h conditioned air to the rooms while the additional chilled ceilings are powered by the vapor compression chiller. The special feature of the system configuration is the installation of two cooling coils in the supply air channel and two heating coils in the exhaust air channel of the air-handling unit. The arrangement of the cooling coils and the additionally use of cold from the compression chiller for the chilled ceilings allows an efficient operation at relatively high chilled water temperatures. Furthermore, the waste heat from the compression chiller is used to pre-heat the regeneration airstream, which leads to a reduction of the heat demand of the solar driven heating side.

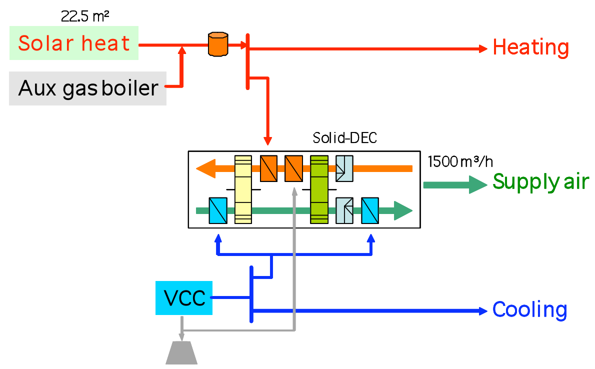


Figure 5. Sketch of the system and the installation of the air-handling unit of the solar assisted DEC-System at the University of Palermo in Italy (*source: DREAM*).

SOLAR THERMALLY DRIVEN HEATING AND COOLING VS. PHOTOVOLTAICS?

Photovoltaic technologies have shown a tremendous market increase and corresponding cost reduction in recent years. Therefore, the question arises which type of solar system should be installed in a given application and building. This question cannot be answered in a simple way, and of course, depends on many boundary conditions such as load profiles, cost of conventional energy, etc. To start to answer such questions, simulations of different system solutions can be used. The results of a simulation study conducted for a hotel building in Madrid, Spain shows:

- A conventional reference system consisting of a natural gas fueled condensation boiler to cover the energy demand for heating, hot water and a vapour compression chiller to cover cooling. Electricity demand is completely covered by the public grid.

- A system using a solar thermal collector to partly cover heating, hot water demand and a natural gas fueled condensation boiler to cover the rest of heating and hot water. A vapour compression chiller is used to cover cooling. Electricity demand is completely covered by the public grid.

- A system using a solar thermal collector to partly cover heating and hot water demand and to operate a thermally driven chiller that covers part of the cooling. A natural gas fueled condensation boiler is used to cover the rest of the energy demand for heating and hot water and a vapour compression chiller to cover the rest of the cooling demand. Electricity demand is completely covered by the public grid.

- A system consisting of a natural gas fueled condensation boiler to cover the energy demand for heating and hot water and a vapour compression chiller to cover cooling. In addition, a photovoltaic (PV) system is used to cover part of the electricity demand. Electricity demand that is not covered by the PV is covered by the public grid. PV electricity that exceeds the electricity demand is fed into the public grid.

Madrid Hotel

The main outcomes of this comparison in terms of energy saving (fractional saving of primary energy in comparison to the conventional reference) and cost (fractional cost difference in comparison to the conventional reference) are shown in Figure 5.

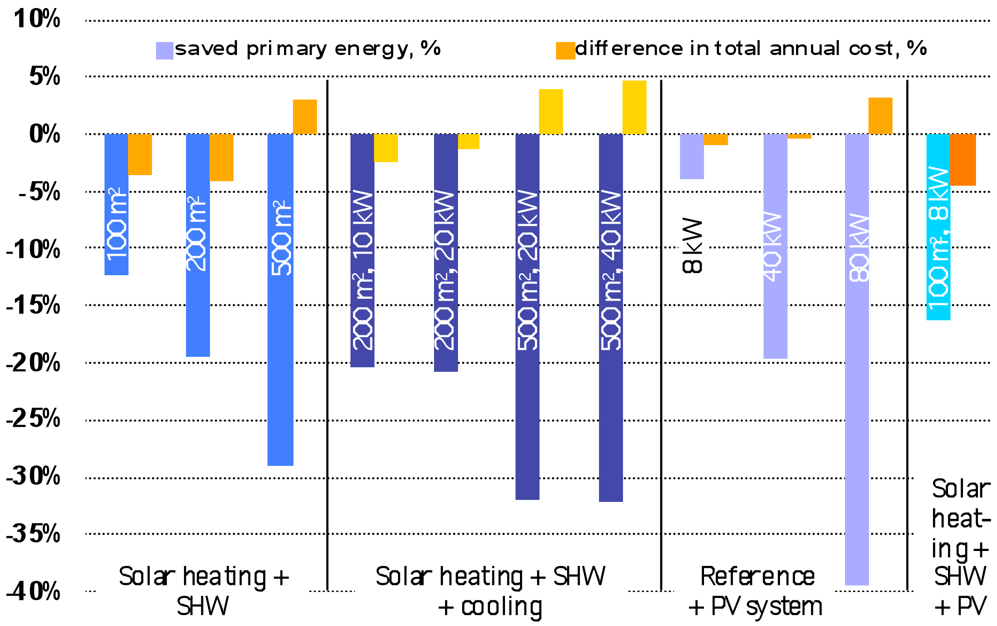


Figure 5. Primary energy (fractional primary energy saving) and difference in total annual cost (fractional cost saving) for different solar assisted solutions in comparison to the conventional reference system (SHW = sanitary hot water).

Each of the investigated systems led to primary energy savings. Figure 5 also indicates that a comparatively small solar thermal system (100 m^2, 200 m^2) for heating and hot water leads to a cost saving (that is, the system amortizes within its lifetime under the conditions made). The cost saving is less pronounced when the solar thermal system is also used for cooling. Large solar thermal systems (500 m^2) lead to higher total annual cost compared to the conventional solution, in other words, such a system does not amortize within its assumed lifetime. Installation of a small to medium sized photovoltaic system (8 kW_{peak} to 40 kW_{peak}) in addition to the conventional system leads to a negligible difference in total annual cost. A large PV system (80 kW_{peak}), however, leads to an increase in total annual cost. The reason being that often electricity is produced that can not be consumed onsite and therefore is fed into the grid at a feed-in tariff which amounts to 50 % of the rate for purchased electricity in this study.

In addition to the systems described above, Figure 5 shows a configuration in which a small solar thermal system (100 m^2) and a small PV system (8 kW_{peak}) are installed together. It is interesting to note that such a solution leads to the largest decrease in total annual cost (that is, shortest payback period).

Conclusions from the Comparisons

The results shown in the example above are specific for the given boundary conditions, in particular the climatic conditions, which influence both the solar gains and the load, and the load conditions, which are typical for a hotel. Results will certainly turn out differently for other buildings and uses. Nevertheless, some general conclusions can be drawn from this example, which are generally valid for the design of energy supply systems in buildings, and in particular, for the use of solar energy systems in buildings.

- Solar thermal systems will be justified in most cases with a high demand for hot water. These systems are most cost efficient if they are sized so that no significant excess heat is produced by the solar collectors.

- Solar thermally driven cooling is an interesting option for making use of high solar gains during the cooling period. Again, the system will be more cost efficient if designed with limited solar fractions. However, this solution is still less cost efficient in comparison to solar thermal systems without cooling. Future improvements and higher production rates will lead to lower costs of thermally driven cooling devices and more standardization in system design, which will lead to a saving in planning and installation costs. Therefore, a significant potential for lowing solar heating and cooling system costs exists.

- In many countries, photovoltaic systems rely on high feed-in tariffs and on an almost infinite grid capacity. Therefore, if the high feed-in tariff is taken into account any PV solution will be much more interesting from a cost point of view than for most solar thermal systems. However, this situation will change drastically in the future with increasing production of electricity from renewable sources. Grid issues will become much more important and the pressure for locally produced electricity (e.g., from PV) will increase and also to be consumed onsite.

- In particular for solar thermal systems – but in future also for PV systems – a detailed assessment of the correlation between solar gains and onsite loads is important. This analysis can usually only be completed through simulation of both the load side and the production systems on a sufficiently narrow time scale. Typically, simulation based on hourly values provides a good basis for a sufficiently detailed analysis.
- A holistic approach to study different combinations of technologies is needed in order to identify the

“best” solution for a given project. Combined energy-cost-performance analysis and corresponding goal functions can provide a guide to the overall “best” solutions.

OUTLOOK

Several thermally driven air-conditioning technologies are available on the market that make possible the use of solar thermal energy in this large field of possible applications. Solar driven or solar-assisted air-conditioning can lead to remarkable primary energy savings if the corresponding systems are properly designed, installed and operated. Aspects required are the appropriate dimensioning of the collector field size and the storage devices as well as the heat and cold backup sources. Particular care must be given to the design of the heat rejection system and all other auxiliary components in order to minimize electricity consumption.

The main challenge for the future is how to achieve high quality systems while increasing market deployment. This will require greater standardization of systems, solutions and tools for planning. At present, a follow-up of SHC Task 38 is in preparation that aims to address these needs.

Task 36

Solar Resource Knowledge Management

Dave Renné
National Renewable Energy Laboratory
Operating Agent for U.S. Department of Energy

TASK DESCRIPTION

Goal and Objectives

The goal of SHC Task 36 "Solar Resource Knowledge Management" is to provide the solar energy industry, the electricity sector, governments, researchers, and renewable energy organizations and institutions with the most suitable and accurate information of the solar radiation resources at the Earth's surface in easily-accessible formats and understandable quality metrics. The scope of solar resource assessment information includes historic and currently derived data products using satellite imagery and other means.

There are three main objectives of this Task to achieve this goal:

- To provide further standardization and benchmarking of international solar resource data sets to insure worldwide Intercomparability and acceptance
- To provide improved data reliability, availability and accessibility in formats that address specific user needs, and
- To develop methods that improve the quality and the spatial and temporal coverage of solar resource products, including reliable long term historical solar radiation databases as well as near-term and long-term irradiance forecasts.

Achieving these objectives would reduce the cost of planning and deploying solar energy systems, improve efficiency of solar energy systems by more accurate and complete solar resource information, and increase the value of the solar energy produced by solar systems.

Scope of the Task

This Task focuses on the development, validation, and access to solar resource information derived from surface-based and satellite-based platforms. The Task will investigate benchmarking and data quality assessment procedures for data products and validation data sets, examine means by which the data can be made easily available to users through various web-based hosting schemes, and conduct studies on improving the input data sets and algorithms from which satellite-derived products are produced. These studies include the investigation of short-term irradiance forecasting and past and future climatic variability of the solar resource.

The audience for the results of the Task includes the technical laboratories, research institutions and universities involved in developing solar resource data products. More importantly, data users, such as energy planners, solar project developers, solar system operators, architects, engineers, energy consultants, product manufacturers, and building and system owners and managers, are the ultimate beneficiaries of the research, and will be informed through targeted reports, presentations, web sites, handbooks and journal articles.

Means

Task 36 participants are addressing the objectives through sharing a co-coordinated work plan encompassing three subtasks:

Subtask A: Standard Qualification for Solar Resource Products

The objective of this Subtask is to provide the user community with benchmarked, standardized, validated worldwide solar resource data sets. Key Subtask activities to meet this objective are:

- Select and Qualify Ground Data Sets (lead: NASA, USA)): this activity will include a survey and documentation of existing data sources, and the production and reporting of high-quality surface data sets with which to use in benchmarking and validating satellite-derived data sets.

- Define Measures of Model Quality for Product Validation (lead: H2Magdeburg, Germany): besides defining measures of model quality, this activity includes the establishment and documentation of model intercomparison procedures.
- Develop Methodology for Establishing Coherent Benchmarking of Products (lead: NASA, USA)
- Apply Benchmarking Procedures to Subtask C Products (lead: H2Magdeburg, Germany): this activity will provide results of benchmarking studies conducted on data sets provided by Task 36 participants

Subtask B: Common Structure for Archiving and Accessing Data Products

The objective of this Subtask is to provide a user-oriented information system, such as a distributed data system, for archiving and accessing solar resource data. Key subtask activities to meet this objective are:

- Evaluate the Legal Aspects of Accessing Solar Resource Data (lead: Armines, France): this activity focuses on establishing copyright and proprietary rights of data that will be made available through the distributed data system, and to establish appropriate protocols with each participating institution for making the data generally available to the public.
- Identification of User Requirements (lead: SUNY/Albany, USA and JRC, EU): this activity captures and examines needs expressed by users of the data and the outcomes are specifications for the information system, list of customers serving later as testers of the prototypes and guidance to subtask A for selection of algorithms and methods
- Develop Data Exchange Protocols and Metadata (lead: Armines, France): various data exchange protocols will be examined, and one will be selected and documented.
- Develop Prototype (lead: Armines, France): a prototype web-based system will be developed whereby a user can request information of a certain type and format, and the information system provides the response or responses that most closely addresses the request.
- Develop Network of Resource Providers (lead: NASA, USA): a worldwide network of data providers will be established, and the techniques for data exchange among the providers will be investigated.
- Develop Use of Prototype by Users (lead: Armines, France): this activity defines the prototype that can be accessed by users, and raises the awareness of the data exchange system to external users.
- Define Automatic Access by Commercial Applications (lead: NASA, USA): This activity will enable automatic and fast access of resources through the information system by using commercial applications.
- Develop a Test Application (Solar Micrositing) (lead: JRC, EU): a case study in micro sitting of a solar energy system will be developed to demonstrate the benefits of the information system.

Subtask C: Improved Techniques for Solar Resource Characterization and Forecasting

The objective of this Subtask is to conduct essential R&D to improve the accuracy and the spatial and temporal coverage of current techniques, including the introduction of solar resource forecasting products. Key activities to meet this objective are:

- Improve Satellite Retrieval Methods for Solar Radiation Products (lead: SUNY/Albany, USA): This activity will focus on key model input parameters and methodologies, such as cloud indices, radiative transfer schemes, aerosol data retrievals, and treatment of snow and other surface albedo artifacts. The activity also addresses ways of improving the spatial resolution of satellite-derived broadband solar resource products.

- Conduct Climatological Analysis of Solar Resources (lead: NASA, USA): In order to ascertain future impacts on system performance due to climate variations, this activity includes the analysis of long-term surface and satellite-derived data sets and climate models; specifically addressing natural long-term fluctuations associated within the ocean-atmosphere system, such as the Southern Oscillation/El Nino.
- Evaluate Solar Radiation Forecasting Procedures (lead: EHF, Germany): This activity investigates different approaches for developing solar resource forecasts based on global numerical weather predictions and extrapolation of cloud motion vectors

Collaboration with other IEA Programmes

Knowledge on solar resources is highly important for all forms of solar energy applications. Therefore Task 36 is conducted as a collaborative Task together with the IEA Implementing Agreements SolarPACES (Solar Power and Chemical Energy Systems), and is designated as Task 5. Task 36 also maintains collaboration with the IEA PVPS (Photovoltaic Power Systems). Both of these Implementing Agreements have agreed that SHC coordinates the Task. Cooperation is based on "minimum level" according to the SHC "Guidelines for Co-ordination with other Programmes."

Task Duration

The Task was initiated July 1, 2005 and will be completed June 30, 2011. At the 66th ExCo meeting in Nice, France in November 2009 the IEA/SHC ExCo granted a one-year extension of the task to allow for additional benchmarking studies and to transition the web portal from the MESoR (Management and Exploitation of Solar Resources) project to Task 36.

Task Deliverables

A number of deliverables have been identified for Task 36, including conference papers, journal articles, workshops, and subtask summaries. The major deliverable will be a Handbook on Solar Radiation, summarizing the key results of all subtasks, planned for publication in mid-2011.

ACTIVITIES DURING 2010

Overall Task Activities

Progress on all aspects of Task 36 continues to be made. Following the completion of the EU-funded program Management and Exploitation of Solar Resource Knowledge (MESoR), which paralleled Task 36 activities and involved most of the European Task 36 participants, the Task participants focused on finalizing their results and developing plans for a new task.

The 8th Task Experts Meeting was held at IEA Headquarters in Paris, France on 8-11 March. About 25 task participants attended, the meeting, which consisted of two parts: 1) a review of progress to date, and 2) a task definition workshop to outline a new Task Annex. Task 36 was scheduled to be completed by June 30, 2010, however, at the 66th SHC ExCo meeting in Nice, France (November 2009) it was agreed to extend the task by one year in order to allow time for the preparation of a new task annex and for completion of a key deliverable. At the Paris meeting it was also decided to modify the final Task 36 deliverables as follows: produce Subtask reports for each of the subtasks, summarizing the work accomplished, and 2) incorporate the critical information into a handbook on solar resources (the planned final deliverable) in mid-2011.

The 9th Task Experts Meeting was held at in conjunction with the Eurosun 2010 Conference in Graz, Austria. About 15 task participants attended the meeting, including several via webinar. The meeting focused on development of a Draft Annex for a new task titled "Solar Resource Assessment and Forecasting". The Annex was presented to the IEA/SHC 68th ExCo meeting in Cape Town, South Africa in November 2010, and was approved as Task 46, to commence on 1 July 2011.

A number of papers were presented by task participants at Solar 2010 in Phoenix, Arizona, the 25th European PV Solar Energy Conference, the SolarPACES Conference in Perpignan, France, and the Eurosun 2010 Conference in Graz, Austria.

Liaison work continues with the Global Earth Observation System of Systems (GEOSS), the United Nations Environment Programme's (UNEP's) Solar and Wind Energy Resource Assessment (SWERA) Program, the International Renewable Energy Agency (IRENA), the Multilateral Working Group on Solar and Wind Energy Technologies and the IEA's World Energy Outlook team by several task members.

Specific Technical Achievements

Subtask A: Standard Qualification of Solar Resource Products

Work on this task has been essentially completed, and the Subtask Leader, Hans Georg Beyer, has relocated to Norway. In 2009 a data collection and QC procedure was completed under the MESoR project. The "first order" benchmarking involves the use of root mean square differences and mean bias differences, expressed in percentages. "Second order" involves Kolmogorov-Smirnoff (KSI) statistics, and this procedure depends very much on the number of data samples available. In general, satellite-derived irradiance data, especially DNI data, do not show the same distribution properties as ground measured data.

Corrections to satellite-derived data are generally done using parallel ground observations at the same location as the satellite pixel or model grid. Up to now, this has been done primarily with monthly or annual data sets by adjusting the observed biases between the satellite and ground station. An extended approach developed under Subtask A is to correct the distributions of the satellite data set according to the distribution of the ground data. Once the distribution of the satellite data is corrected according to this approach, the second step is to use what we have learned from correcting the distribution function to correct the individual values of the satellite-derived time series data. This is done by mapping the original values to the target values according to the value of the cumulative distribution, as depicted in Figure 1, which results in a corrected satellite distribution as shown in Figure 2.

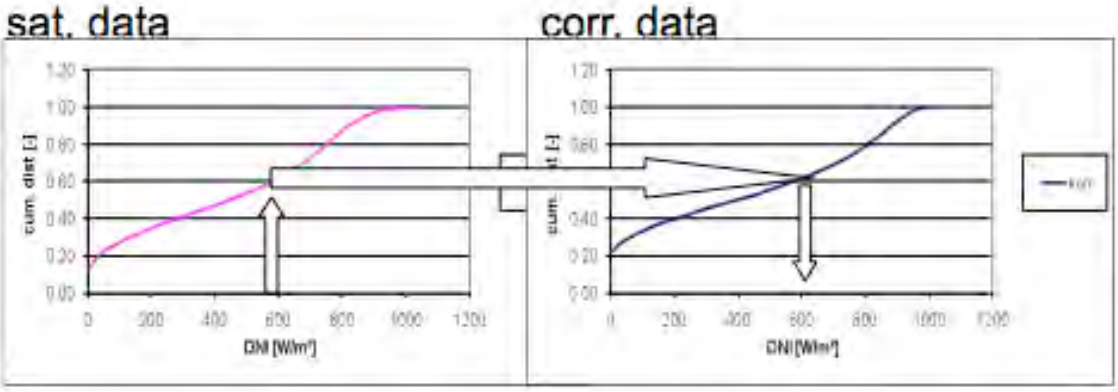


Figure 1. Correcting satellite-derived DNI data distributions with ground observations.

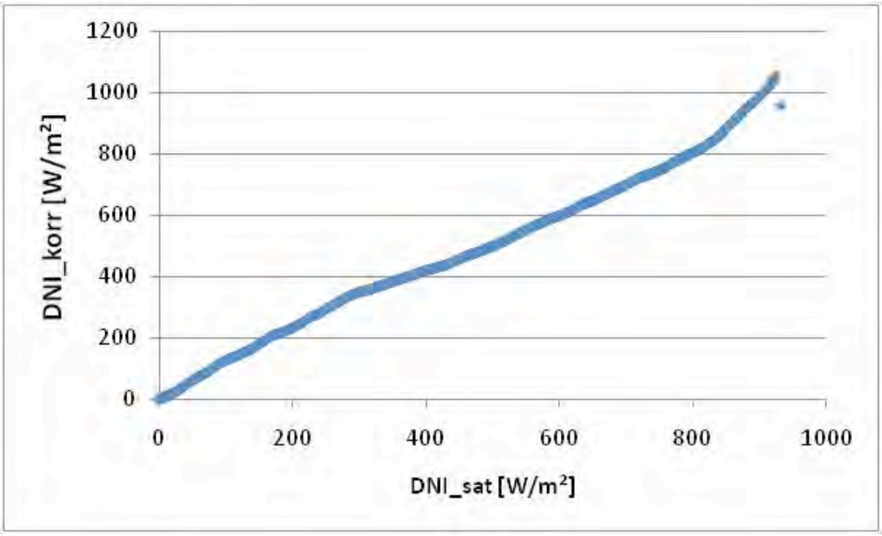


Figure 2. Resulting corrected satellite-derived DNI data based on the example of Figure 1.

Environment Canada and *Natural Resources Canada* have collaborated to develop a CCD fiber optic spectrometer system for the near instantaneous measurement of spectral global, direct, diffuse, reflected and southward-tilted irradiances from 0.3 µm to 1.0 µm. Recent results (Morley et. al, 2010) were presented and published in the proceedings of the conference for the Society of Photo-Optical Instrumentation Engineers (SPIE) in San Diego, California, U.S.A., from August 1 – 5, 2010. The results include a description of system components and an assessment of the spectrometer's measurement accuracy.

The accuracy of global irradiance was examined by comparing measurements against global photosynthetically active radiation (PAR) (0.395 – 0.695 µm) from *Eppley* red and green dome pyranometers. PAR daily totals (MJ/m^2/day) and one-minute averages (W/m^2) were compared for 35 days in 2009 at Environment Canada's BSRN Bratt's Lake Observatory (BLO). After corrections for the spectrometer's temperature dependency and cosine errors inherent to the spectralon diffusers, daily totals were found to be within ± 10% from June to October (Figure 1). The poor results from November and December imply that further improvements to the above corrections are required.

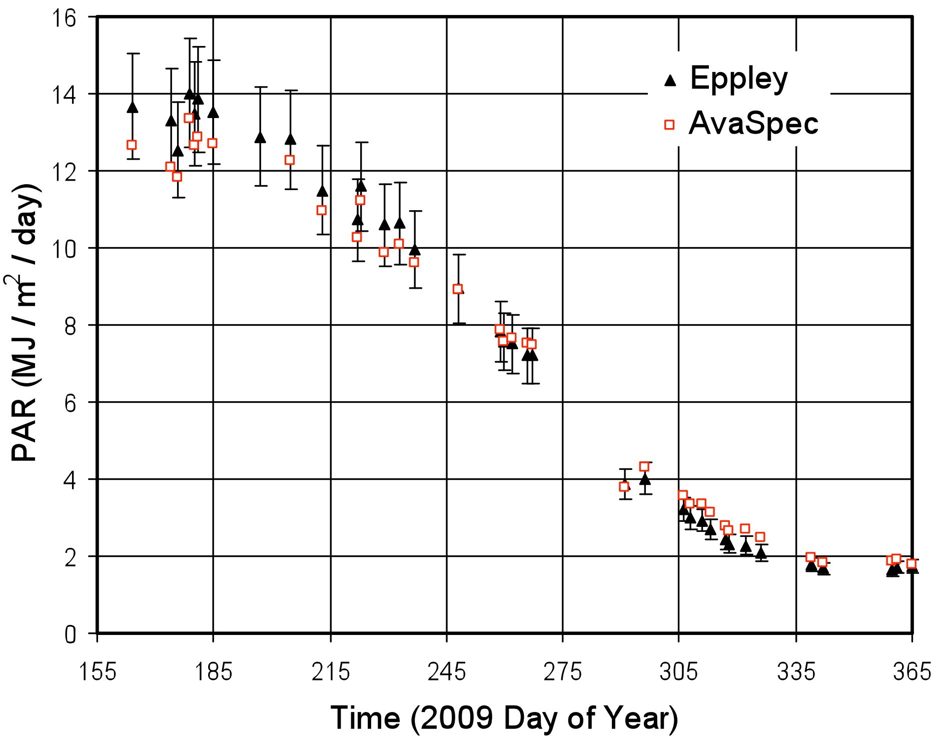


Figure 3. Global PAR daily totals (MJ/m^2/day) from the *Eppley* PSP and AvaSpec2048-TEC for 35 days in 2009 at BLO. Note: horizontal bars represent ± 10% difference from the *Eppley* PSP values.

Subtask B: Common Structure for Archiving, Processing, and Accessing Resource

GeoModel Solar s.r.o. has developed and implemented new methods for an interactive map-based portal SolarGIS. The portal effectively links to continental databases of Global Horizontal and Direct Normal solar radiation, air temperature, Digital Elevation Model SRTM-3, and to other geographic data, such as population density and land cover. The extent of the database is based on coverage by the Meteosat Prime and IODC satellites, which cover most regions of Europe, Africa, Asia, and Eastern part of South America.

The new set of algorithms have been developed and implemented to perform on-line simulation of solar radiation for any tilted or sun tracking system and simulation of PV systems using a new concept of statistically-aggregated time series of solar radiation and air temperature. This approach enables fast simulations, considering the non-linear nature of modeling in solar radiation and PV. The SolarGIS web interface is supported by state-of-the-art mapping technology and implementation of very high-resolution continental maps. Implementation of new methods for solar radiation disaggregation (see below the work of Ruiz-Arias et al. 2010), and custom-tailored design of the databases, allows the user to conduct interactive micrositing using on-the-fly data with spatial accuracy up to 90-m (Figure 4).

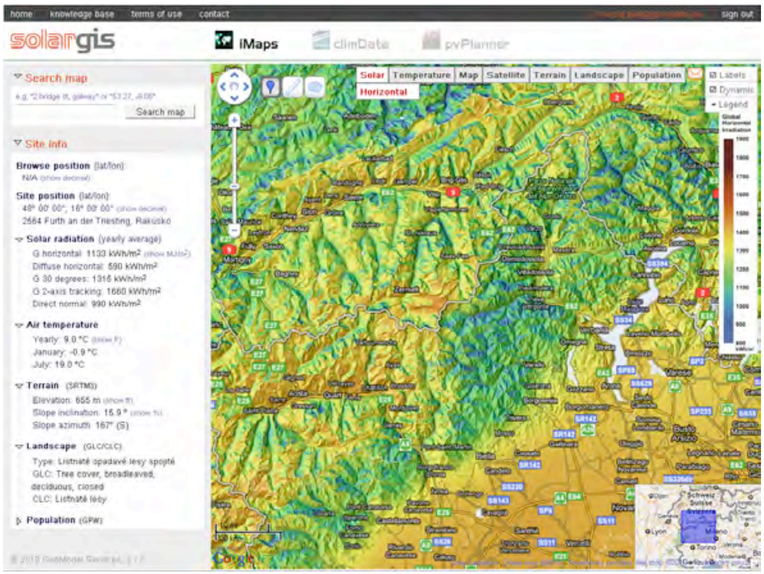


Figure 4. SolarGIS iMaps – providing interactive access to solar radiation database and high-resolution maps on a continental scale (Suri and Cebecauer 2010).

The main innovative features of the SolarGIS web system are:

- High-resolution databases developed by new and improved solar algorithms that have been extensively validated and documented in publications.
- Implementation of fast-access data structure to store, interactively process and display large volumes of information.
- Fast and easy-to-understand access to climate information and simulation tools via web-based services.
- Detailed interactive maps, precise geo-positioning and standardized PDF report generation.

This work was presented by Suri and Cebecauer at the EuroSun 2010 Conference in Graz, Austria (October 2010) and awarded a prize for best poster (Suri and Cebecauer 2010).

The experience from SolarGIS will be implemented in the new international initiative lead by DLR "Solar Resource Atlas for the Mediterranean".

The other Activities in this Subtask have been completed. Liaison with the Global Earth Observation System of Systems continues, with a focus on adapting best practices methodologies for web portal design. This work will continue in the new Task 46, which begins in July 2011.

Subtask C: Improved Techniques for Solar Resource Characterization and Forecasting

Activity C1: Improve Satellite Retrieval Methods for Solar Radiation Products.

Model development work was undertaken by GeoModel Solar s.r.o. (T. Cebecauer and M. Suri, 2010) in collaboration with R. Perez from SUNY. This model is based on the framework of the SUNY/NSRDB model and includes a number of new features designed to enhance accuracy of calculations, including:

- Utilization of Meteosat Second Generation (MSG) spectral channels to both detect snow conditions and palliate to the weaknesses of the visible-channel based model under high-albedo conditions resulting from specific local surface properties (e.g. salt lakes). The snow cover detection methodology is an adaptation of the method proposed by Durr and Zelenka (2008);

- Implementation of the simplified Solis model (Ineichen 2009);
- Better representation of daily variability of solar radiation (especially DNI) due to integration of the GEMS/MACC aerosol data;
- Enhancing the dynamic range to capture both ground albedo and cloud top variations over time of year, time of day and space;
- Downscaling solar irradiance with high-resolution terrain information (Ruiz-Arias et al. 2010).

This approach was adapted to the Meteosat First Generation family of satellites and implemented in the SolarGIS framework for operational calculations to Meteosat PRIME and IODC regions, covering most regions of Europe, Africa, Asia and Eastern part of South America. Figure 5 provides an example for southern Africa
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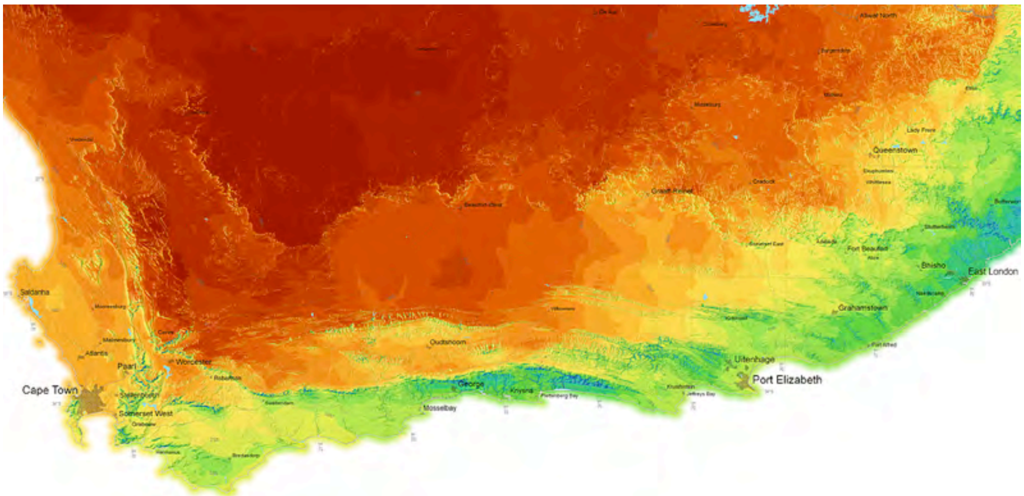

Figure 5. Subset of the database calculated by the SolarGIS approach (South Africa): annual sum of Direct Normal Irradiation (Cebecauer et al. 2010).

The approach has been implemented in operational calculations of solar irradiance for the Meteosat MSG satellite. The report detailing this work was presented at the SOLAR 2010 National Solar Conference in Phoenix, Arizona (USA); see Cebecauer et al. 2010.

A contribution from the University of Jaén (J.A. Ruiz-Arias and J.Tovar-Pescador) and GeoModel Solar s.r.o. (T. Cebecauer and M. Suri) validates the usefulness of a Digital Elevation Model (DEM) dataset to reduce the bias present in the satellite-retrievals-based irradiance maps by the unaccounted terrain shading at high solar zenith angles. The methodology was validated in the southern mountainous part of the Iberian Peninsula, and has been implemented operationally (Figure 6). Inclusion of the topographic information from the DEM enhanced the spatial resolution of the irradiance maps from 3 arc minutes (~90 m) and reduced the mean bias error along the region from 2.3% to 0.4%. The correction, indeed, proved to be highly dependent on the DEM reliability. Some other aspects of the spatial variability of the irradiance have been also discussed within this work.

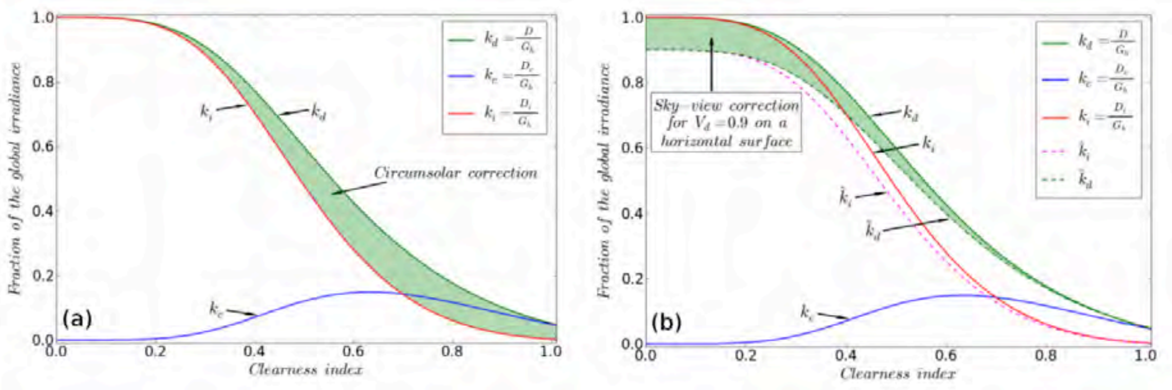

Figure 6. Left: Relative importance of the correction of the circumsolar diffuse component shaded by a horizon as a function of the clearness index. Right: Relative importance of the sky view factor correction on the isotropic diffuse irradiance as a function of the clearness index (Ruiz-Arias et. al 2010).

One of the main outcomes of the European project GEMS is a new atmospheric dataset - a product of re-analysis computed by the European Center for Mid-Range Weather Forecasting (ECMWF). This dataset also includes parameters characterizing Aerosol Optical Depth and total water vapor. The data are a result of new developments in the assimilation of aerosol sources and modeling within the framework of Integrated Forecast System run by ECMWF.

This GEMS AOD data set was incorporated into the computing chain of the new SolarGIS satellite-based model and analyzed by T. Cebecauer and M. Suri. The new set up better captures daily variability of solar irradiance, especially events with extreme atmospheric loadings of aerosols and water vapor. Thus it reduces uncertainty of instantaneous GHI and especially DNI estimates. Main accuracy improvements were achieved in reduction of Root Mean Square Deviation (RMSD) and improved distribution functions. Analysis data for 9 Spanish sites, Sede Boqer and Tamanrasset, for the satellite model based on the GEMS atmospheric dataset show an overall mean bias of DNI at -3.1 W/m2 (-0.9%), standard deviation of biases at 6.4% and RMSD for hourly values at 123 W/m2 (35.7%). Examples of these analyses are shown in Figures 7 and 8.

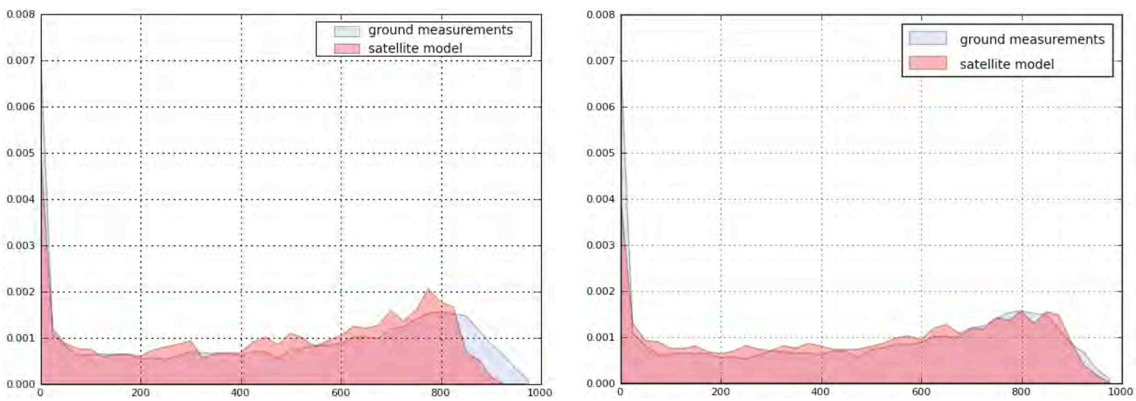

Figure 7. Frequency distribution of DNI values [W/m^2] for Valladolid (Spain). Left: results based on the AOD and water vapor long-term monthly averages. Right: results based on daily values from the GEMS database (Cebecauer and Suri 2010).

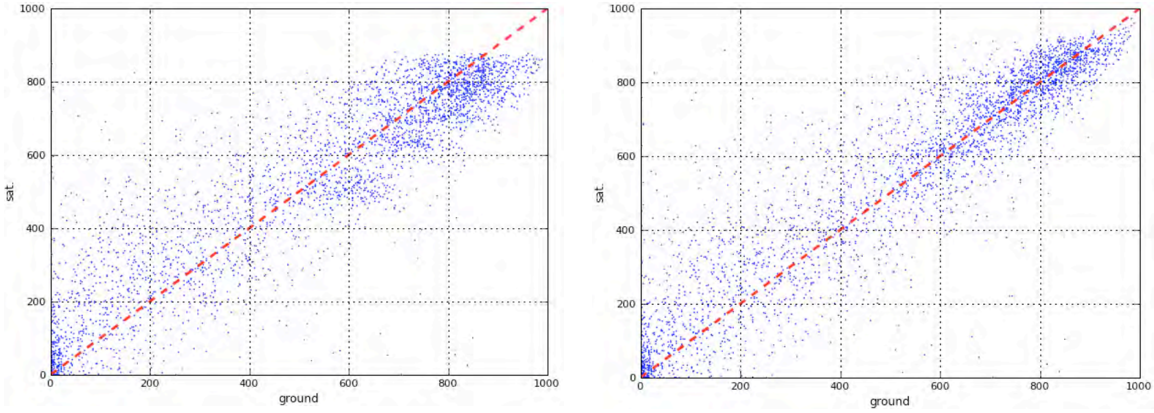

Figure 8. DNI from satellite model compared to ground measurements (Badajos, Spain). Left: model using AOD and water vapor long-term monthly averages. Right: model using daily values from the GEMS database (Cebecauer and Suri 2010).

The report detailing this work was presented at the SolarPACES 2010 Conference (Cebecauer and Suri 2010).

Combining satellite data with local ground measurements aims to improve accuracy of the integrated solar irradiance values and time series. A common problem of satellite derived DNI databases is disagreement of frequency distribution functions compared to ground measurements, which limits the potential to record the occurrence of extreme situations (e.g. very low atmospheric turbidity resulting in high DNI). A method enhancing accuracy of the SolarGIS satellite database using the ground measurements was presented by T. Cebecauer and M. Suri of GeoModel Solar s.r.o. in collaboration with R. Perez from SUNY. The work focused on the improvement of the overall bias on the fit of frequency distribution functions.

The enhancement of the DNI accuracy is usually done for the satellite data covering a longer period of data (e.g. several years) using high-quality ground measurements, which cover a shorter period of time, usually several months to one year. This type of enhancement assumes that the systematic error/deviation exists in the satellite data and the magnitude of this deviation is invariant over the time. An example is shown in Figure 9. However, the ground measurement campaign has to be long enough to be representative of the type of deviation present in the satellite-derived database. If the ground data are not capable to cover the type of the deviation to be corrected, such enhancement may result in a degradation of the overall satellite data accuracy.

On the example of five ground stations, two types of correction were made:

- For prefeasibility studies, DNI long-term monthly and annual averages are calculated using correction of bias;
- For feasibility studies and due diligence, enhanced hourly and 15-minute time series are produced with corrected cumulative probability distribution function.

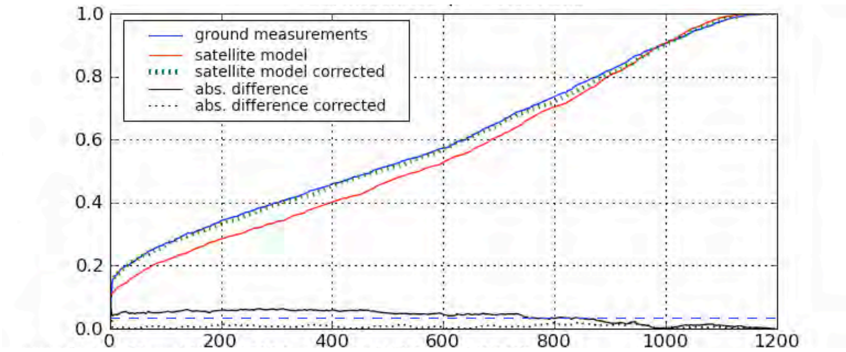

Figure 9. Correction of DNI (W/m2) cumulative distribution of DNI values for Cordoba.

For all selected sites, an improvement was achieved in the sense of overall bias and/or cumulative frequency functions, especially for sites with high deviation. The enhancement is effective for mitigating systematic problems in the satellite-derived data such as under/over-estimation of local aerosol loads. In such cases the analyzed methods may be good for adaptation of satellite derived DNI datasets for microclimatic conditions in complex environmental situations that cannot be recorded in global solar irradiation and atmospheric datasets. The enhancement based on the fit of cumulative distribution of DNI values may be especially effective when specific situations such as extreme irradiance events are important.

This work was presented at the SolarPACES 2010 Conference in Perpignan (Suri et al. 2010).

Aerosol extinction reduces direct normal irradiance significantly. Currently, aerosol climatologies with a coarse temporal and spatial resolution are used in solar surface irradiance schemes based on satellite imagery. DLR assesses numerical modeling of aerosols as used in the aerosol science community and demonstrates the influence of different aerosol data sets on direct normal irradiances. A 25-year reanalysis dataset based on a chemical transport model is used to compare a daily numerical modeling versus state of the art use of aerosol monthly mean climatologies. Additionally, modeled aerosol optical depth is validated against ground measurements and the potential of improved direct normal irradiance modeling is shown. A global climatology of mineral dust aerosol load and the number of occurrence of dust events with irradiance extinction of more than 5, 10, 20, and 30 % were derived. Fig. 10 shows the number of days with global irradiance extinction above 10 %, while Fig. 11 shows the number of days with direct irradiance extinction above 10 % as a multi-annual average map for Europe, North Africa and the Middle East (EUMENA). Maximum values can be observed close to the dust source regions in the Sahara and the Middle East, while other regions are affected by dust transports during a number of days per year, such as Southern Spain, where up to 80 days per year of direct irradiance extinction above 10% is caused by dust. (Schroedter-Homscheidt et al 2010

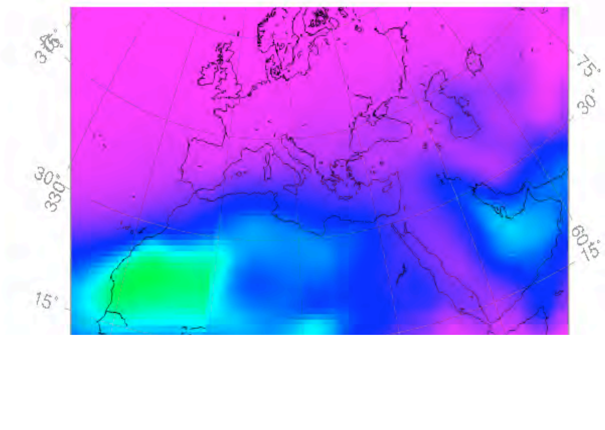

Figure 10. Number of days with a global irradiance extinction above 10% based on a 1983 -2007 DLR/ MATCH reanalysis for the EUMENA region.

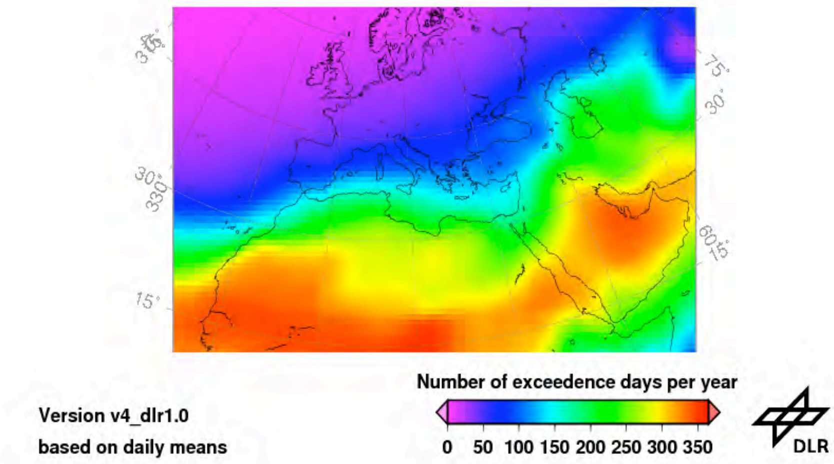

Figure. 11. Number of days with a direct irradiance extinction above 10% based on a 1983 - 2007 DLR/MATCH reanalysis for the EUMENA region.

Activity C2: Conduct Climatological Analysis of Solar Resources.

Meteotest (Switzerland) has been examining long-term trends based on data archived in the Global Energy Balance Archive (GEBA). A complete report on this study was recently presented at Eurosun 2010 by Remund and Müller (2010). The study shows that the phenomenon of global dimming and brightening has been confirmed. The positive trend since 1985 is visible in Europe until last year and is in the range of 4 W/m^2 and decade. However there are signs of a decline of the trend after 2005.

Looking at the moving averages with smoothing lengths of e.g. 20 years, the changes are generally small. The standard deviation of a 20-year mean is in and around Germany in the range of 1.5 – 2.0%, which is below the uncertainty of the measurement itself. The use of the 20-year mean 1981 – 2000 leads in Germany to an underestimation of 2 – 3 % compared to the time period 1986 – 2005. In most other regions the trends are smaller or, like in China, even reversed.

These signs are confirmed by satellite-derived data sets developed by NASA/LaRC, as shown in Figure 12, which present the de-seasonalized monthly anomalies of the downwelling solar irradiance (in W m^{-2}) in the zonal averaging latitude bands of 60°N – 60°S and 20°N - 20°S in the top panel. The anomaly of the zonally averaged cloud amount is also included in this figure. These data are derived from the NASA/GEWEX Surface Radiation Budget project (Stackhouse et al., 2011) and ultimately are used to provide solar resource information through the NASA Surface meteorology and Solar Energy web service (SSE). The bottom panel of Figure 12 shows the time-latitude cross-section of downwelling solar irradiance anomalies. These plots show qualitative agreement with the dimming/brightening short-term changes found in the GEBA archive. Figure 12 also shows that the European decline after 2005 might be true of a larger zonal change. However, it should be noted that at least some of the changes are correlated with the input data stream. Future work will estimate the uncertainties of short-term changes relative to noise and artefact uncertainties. The time-latitude cross-section plot shows the effect of the Mt. Pinatubo eruption and the latitudinal propagation of tropical variability from the El Niño cycles.

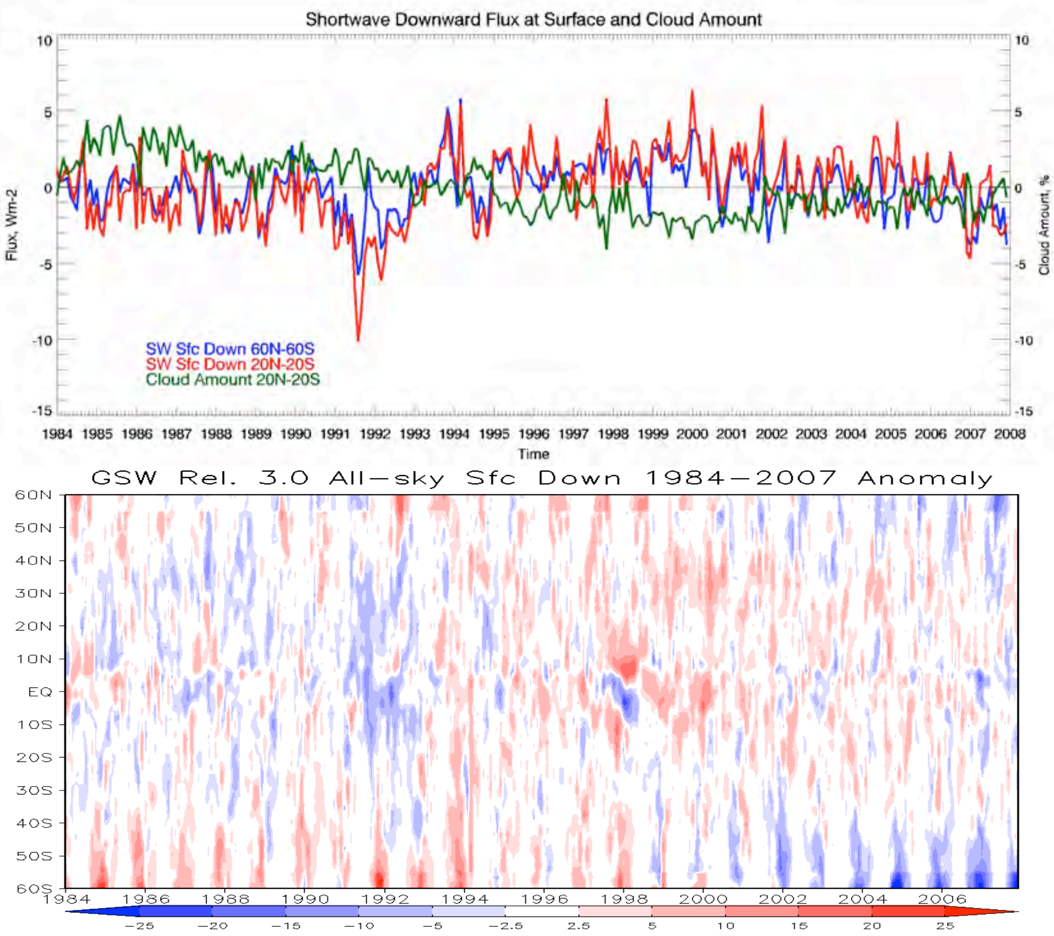

Figure. 12. The de-seasonalized monthly anomaly of the downwelling surface solar irradiance for the zonal averages of 60°N – 60°S and 20°N - 20°S (top panel) and the time-latitude cross-section of the zonal 1° monthly anomalies in W m^{-2}. The top panel also shows the de-seasonalized monthly anomaly of the cloud amount for context.

As the changes in aerosol concentration based mainly on industrial processes (which is dependent on the production and air pollution control) are one of the main reasons for brightening and dimming this conclusions are not astonishing. In India and China industry and power production based on coal still has a strong growth, whereas in Europe and Japan industry has lowered the output of aerosols after 1985. As aerosol loads are now quite stable in Western Europe and will presumably grow in Asia, the brightening phase will presumably not be prolonged in the future.

Remund and Müller (2010) also examined modelled changes in future global radiation for the rest of this century and determined that these are also relatively small and are mostly in the range of a few percent. In contrast to temperature, there are no big changes foreseen in future radiation trends. On a global average the radiation will diminish slightly. In the Mediterranean region however the trend is positive.

Activity C3: Evaluate Solar Radiation Forecasting Procedures.

A major emphasis in Subtask C during the year 2010 was the testing and benchmarking of various solar irradiance forecasting approaches.
The benchmarking of eight different

forecasting algorithms for several regions in Europe for the period 1 July 2007 to 30 June 2008 has been finalized as a joint effort of the European partners. Results have been presented at the 24th European Photovoltaic Solar Energy Conference and Exhibition in Hamburg, and selected results also at the Solar PACES 2009 in Berlin, and summarized in our 2009 Task 36 Annual Report. Figure 13 gives an overview on the locations of the ground measurement stations used for the benchmarking, and Table 1 gives an overview on the forecasting approaches of the task members.

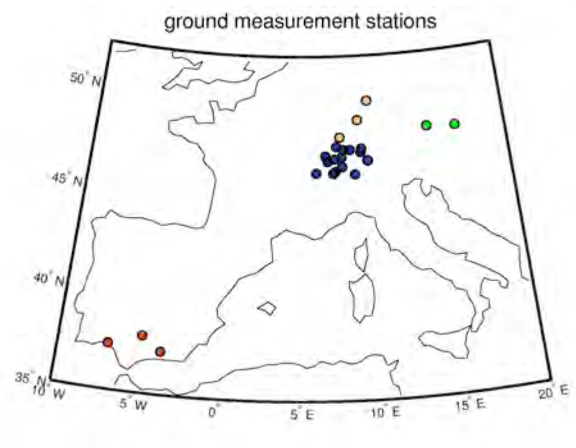

Figure 13. Locations of ground measurement stations for the benchmarking of forecasts. Red: Spanish stations, orange: German stations, blue: Swiss stations, green: Austrian stations.

Table 1. Overview on forecasting approaches of the European partners.

Team	Approach	NWP model with spatial and temporal resolution
University of Oldenburg, German	Statistical post-processing in combination with a clear sky model	ECMWF - 0.25°x 0.25° - 3 hours
Blue Sky, Austria,	a)"human" cloud cover forecast (by meteorologists) b) BLUE FORECAST: statistic forecast tool	for b) GFS - 1° x 1° and 0,5°x 0.5° - 3 hours and 6 hours
Meteo-control, German	MOS (model Output Statistics) by Meteomedia GmbH	ECMWF - 0.25°x 0.25° - 3 hours
Ciemat, Spain	Bias correction	AEMet-HIRLAM - 0.2°x 0.2° - 1 hour
CENER, Spain	Post-processing based on learning machine models	Skiron/GFS - 0.1°x 0.1° - 1 hour
Meteotest, Switzerland	Direct model output of global irradiance, averaging of 10x10 pixels	WRF/GFS - 5km x 5km - 1 hour
University of Jaen, Spain	Direct model output of global irradiance	WRF/GFS - 3km x 3km - 1 hour

Absolute root mean square error (rmse) values for the different approaches are given in Figure 14 for the European countries (Germany, Switzerland, Austria, and Spain). The evaluation revealed a strong dependence of the forecast accuracy on climatic conditions. For central European stations the relative rmse ranges from 40% to 60%, for the Southern Spanish stations relative rmse values are in the range of 20% to 35%. At the current stage of research, irradiance forecasts based on global model numerical weather prediction models in combination with post-processing show best results. All proposed methods perform significantly better than persistence.

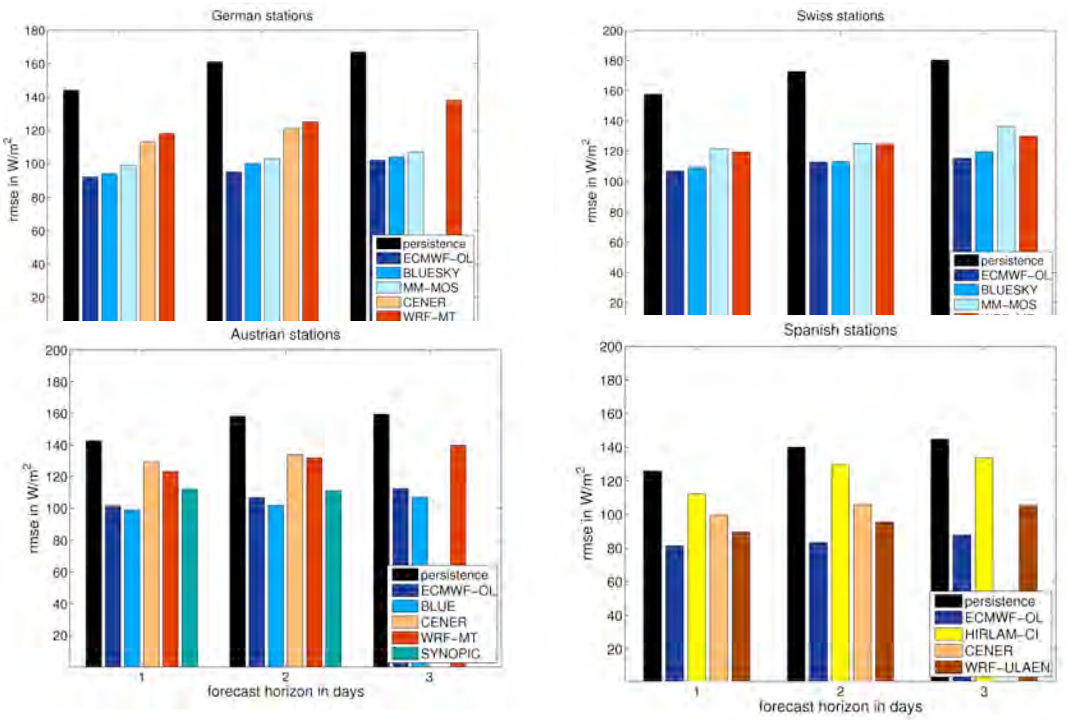

Figure 14. Rmse for the first, second, and third forecast day for stations from Germany (mean=227 W/m2), Switzerland (mean=267W/m2), Austria (mean=222W/m2), and Spain (mean=391W/m2).

In addition to the benchmarking studies for Europe, SUNY/Albany, New York (USA) and Natural Resources Canada (CanmetENERGY) are continuously evaluating forecasts at high quality ground stations in the U.S. and Canada (see, e.g., the paper by Perez et. al presented at Solar 2009). In addition to some of the forecast models shown in Figure 14, the U.S. is evaluating the National Digital Forecast Database (NDFD).

Natural Resources Canada (CanmetENERGY) developed hourly solar and photovoltaic power generation forecasts for the next 48 hours through post-processing of the Canadian Meteorological Centre's Global Environmental Multiscale (GEM) model outputs. The solar forecasts were compared to measured irradiance data from ten North American meteorological stations over a two-year period (1 year of training, 1 year of testing). Forecast accuracy was improved via two post-processing methods: spatial averaging of forecasts and bias removal using a Kalman filter, which lead to an overall reduction of forecast root mean square error (RMSE) of about 14%. Figure 15 shows the results for three ground stations over a one-year period (June 1, 2009 to May 31, 2010). As with the European forecasts, global numerical weather prediction models performed best, with RMSEs of the order of 30 to

40%, intermediate between the Spanish and Central European results. It was found that averaging of the results of different algorithms lead to a slight reduction in errors. These results were highlighted in a Task 36 poster presented at EuroSun 2010.

These solar forecasts were used to develop PV forecasts for three sample PV systems in Québec and Ontario, and to test these PV forecasts over a one-year period. Most of the errors in

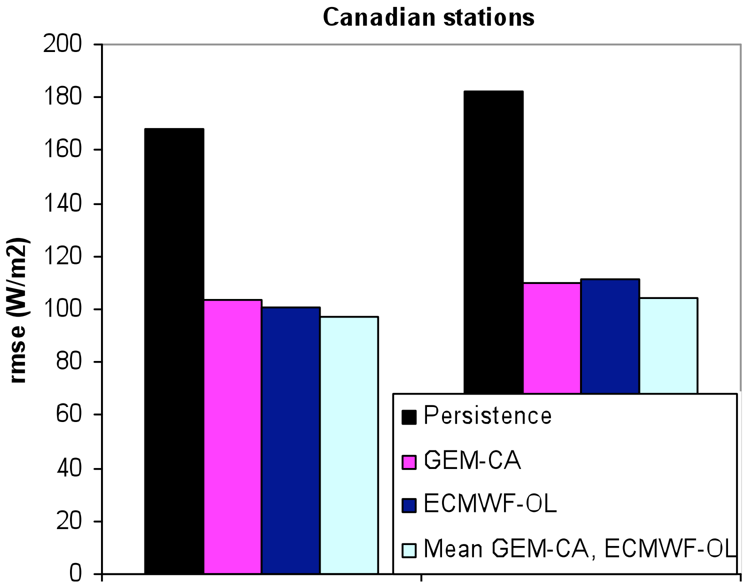

Figure 15. Average root mean square error (rmse) for three Canadian ground stations for 1 and 2-day ahead forecasts.

PV forecasts arise from (horizontal) solar forecasting errors, provided that the PV systems are properly characterized (especially their STC power). Overall, the RMSE and bias of the PV forecasts for individual systems were of the order of 7 to 10 % and 0 to 1% of rated power, respectively (where errors are calculated over all hours of the day). Analysis of the solar forecasts suggests that these errors should be reduced considerably when ensembles of PV systems are considered.

Besides the benchmarking exercises all Task members involved in irradiance forecasting are continuously working on further development of the forecasting algorithms with respect to forecasting global irradiance (GHI). Some institutes (DLR; University of Jaen, University of Oldenburg) also started or continue research with respect to direct irradiance (DNI) forecasts. Furthermore different applications of the forecasts are investigated, e.g. power forecast for PV systems or solar thermal power plants, or the use of forecast information for load management for the integration of a solar thermal power plant into an existing district heating grid.

WORK PLANNED FOR 2011

Task 36, originally scheduled to be completed on 30 June 2010, will now end on 30 June 2011. During the first half of 2011 a Handbook on Solar Radiation will be developed. This Handbook will summarize the major findings of each of the three Subtasks and the Activities within these Subtasks, and provide a review of future work that can be accomplished under the new Task 46, which will start on 1 July 2011.

LINKS WITH INDUSTRY

Several small companies are directly participating in the Task: Suntrace GmbH, Meteotest, Blue Sky Wetter-analyzen, and GeoModel Solar s.r.o. Another task participant has formed a cooperative arrangement with Clean Power Research in the U.S. to market satellite-derive data. The audience for the results of Task 36 includes the technical laboratories, research institutions, and universities involved in developing solar resource data products. More importantly, data users, such as energy planners, solar project developers, architects, engineers, energy consultants, product manufacturers, building and system owners and managers, and utility organizations, are the ultimate beneficiaries of the research, and will be informed through targeted reports, presentations, web sites, handbooks and journal articles.

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MEETINGS IN 2010

Eight Experts Meeting
9-11 March 2010
IEA HQ, Paris France

This meeting focused on a review of Task activities and results in preparation for developing the final task deliverables; a Task Concept Paper for a new task titled "Solar Resource Assessment and Forecasting" was prepared.

Ninth Experts Meeting
30 September 2010
Graz, Austria

A draft work plan for the new task was prepared. The work plan was presented at the 68th Executive Committee Meeting in Cape Town, South Africa on 16-17 November 2010 and accepted as Task 46, with a scheduled commence data of 1 July 2011.

MEETINGS PLANNED FOR 2011

Tenth Experts Meeting
1-3 March 2011
Stuttgart, Germany

Eleventh Experts Meeting and Task 46 Kick-off Meeting
August 2011 (in conjunction with SWC2011)
Kassel, Germany

TASK 36 NATIONAL CONTACTS

Operating Agent
Dave Renné
National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, Colorado 80401-3393 USA
david.renne@nrel.gov

Austria
Klaus Reingruber and Wolfgang Traunmuller
Bluesky Wetteranalyzen
Steinhüblstr. 1, 4800 Attang-Puchheim
klaus.reingruber@blueskywetter.at
wolfgang.traunmueller@blueskywetter.at

Gerald Steinmaurer
Austria Solar Innovation Center
Roseggerstrasse 12, 4600 Wels
steinmaurer.gerald@asic.at

Canada
L. J. Bruce McArthur
Experimental Studies Section, Air Quality Research Division
Environment Canada
4905 Dufferin Street
North York, Ontario
M3H 5T4
Bruce.McArthur@ec.gc.ca

James Morley
Experimental Studies Section, Air Quality Division
Environment Canada
100 R-Y Trail
RM of Bratt's Lake
P.O. Box 160
Wilcox, SK, Canada
S0G 5E0
James.morley@ec.gc.ca

Sophie Pelland and Yves Poissant
Natural Resources Canada
CanmetENERGY
1615 Lionel-Boulet Boulevard
Varennes/J3X 1S6
spelland@nrcan.gc.ca
ypoissant@nrcan.gc.ca

Paul Vaillancourt
Environment Canada
2121 Transcanada Highway
Montreal H9P 153

European Commission
Thomas Huld and Attilio Gambardella
European Commission - DG Joint Research Centre
Institute for Energy - Renewable Energy Unit
I-21020 Ispra (VA), Italy
thomas.huld@jrc.ec.europa.eu
attilio.gambardella@irc.ec.europa.eu

France
Lucien Wald (*Subtask B Leader)* and Lionel Ménard
Centre Energetique et Procedes
MINES ParisTech / Armines
BP 207
F-06904 Sophia Antipolis cedex
lucien.wald@mines-paristech.fr
lionel.menard@mines-paristech.fr

Dominique Dumortier
LASH-ENTPE
Rue Maurice Audin
F-69518 Vaulx-en-Velin
dominique.dumortier@entpe.fr

Germany
Prof. Dr. Hans Georg BEYER
University of Agder
Department of Engineering Sciences
Grimstad, Norway
hans-georg.beyer@uia.no

Richard Meyer
(Task Representative, SolarPACES)
Suntrace GmbH
Brandstwiete 46
20457 Hamburg
Richard.Meyer@suntrace.de

Detlev Heinemann *(Subtask C Leader)* and Elke Lorenz
Carl von Ossietzky Universität Oldenburg
D-26111 Oldenburg
detlev.heinemann@uni-oldenburg.de
elke.lorenz@uni-oldenburg.de

Gerd Heilscher
University of Applied Sciences
Hochschule Ulm
Eberhard Frinckh Str. 11
D-89075 Ulm
heilscher@hs-ulm.de

Carsten Hoyer-Klick and Christoph Schillings
DLR Institut für Technische Thermodanamik
Pfaffenwaldring 38-40
D-70503 Stuttgart
carsten.hoyer@dlr.de
christoph.schillings@dlr.de

Marion Schroedter-Homscheidt
DLR-DFD
Oberpfaffenhofen
D-82234 Wessling
marion.schroedter-homscheidt@dlr.de)

Spain

Martín Gastón, Lourdes Ramirez
(Deputy Task Representative, SolarPACES)
CENER
C/Ciudad de la Innovación 7, 31.621 Sarriguren
mgaston@cener.com
lramirez@cener.com

Jesús Polo and Luis F. Zarzalejo
CIEMAT
División de Energías Renovables
Departamento de Energía
Avda. Complutense, 22
E-28040 Madrid
jesus.polo@ciemat.es
lf.zarzalejo@ciemat.es

Luis Martín
IrSOLaV
C/ Santiago Grisolía, 2
E-28760 Tres Cantos (PTM)
luis.martin@irsolav.com

José Louis Torres, Marian de Blas and Ana Maria Gracia
Public University of Navarro
Dpto. Proyectos e Ingeniería Rural
Edificio Los Olivos
UPNA 31006 Pampiona
jlte@unavarra.es
mblas@unavarra.es
ana.gracia@unavarra.es

David Pozo Vazquez, Jose Antonio Ruiz Arias and Vicente Lara Fanego
University of Jaen
Campus Lagunillas, A3, 23071 Jaen
dpozo@ujaen.es
jararias@ujaen.es
vlara@ujaen.es

Slovakia

Marcel Suri and Tomas Cebecauer
GeoModel Solar, s.r.o.
M. Marecka 3
SK-841 07 Bratislava
marcel.suri@geomodel.eu
tomas.cebecauer@geomodel.eu

Switzerland

Pierre Ineichen
University of Geneva, CUEPE
7 rte de Drize
CH-1227 Carouge Geneva
pierre.ineichen@unige.ch

Jan Remund
Meteotest
Fabrikstr. 14
CH-3012 Bern
remund@meteotest.ch

United States

Paul Stackhouse and Taiping Zhang
NASA Langley Research Center
MS 420
Hampton, VA 23681
Paul.w.stackhouse@nasa.gov
t-zhang@larc.nasa.gov

Richard Perez
State University of New York/Albany
Atmospheric Sciences Research Center
251 Fuller Road
Albany, NY 12203
perez@asrc.cestm.albany.edu

Manajit Sengupta and Daryl Myers
National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, CO 80401-3393
Manajit.Sengupta@nrel.gov
Daryl.myers@nrel.gov

Task 38

Solar Air-Conditioning and Refrigeration

Hans-Martin Henning
Fraunhofer Institute for Solar Energy Systems
Operating Agent for Forschungzentrum Jülich GmbH

TASK DESCRIPTION

In many regions of the world room air-conditioning is responsible for the dominant part of electricity consumption of buildings. Electrically driven chillers cause high electricity peak loads in electricity grids, even if systems are used that reached a relatively high standard concerning energy consumption. This is becoming a growing problem in regions with cooling dominated climates. In addition conventional air-conditioning systems apply refrigerants, which have a significant greenhouse impact. Task 38 worked on environmentally sound solutions for building air-conditioning and refrigeration using solar thermal energy to operate thermally driven cooling cycles.

The main objective of *SHC Task 38, Solar Air-Conditioning and Refrigeration*, was the implementation of measures for an accelerated market introduction of solar air conditioning and refrigeration with a major focus on improved components and system concepts. The market introduction has been supported through:

- Activities in development and testing of cooling equipment for the residential and small commercial sector.
- Development of pre-engineered system concepts for small and medium size systems and development of optimized and standardized schemes for custom made systems.
- Reports on the experiences with new pilot and demonstration plants and on the evaluation and performance assessment procedure.
- Provision of accompanying documents supporting the planning, installation, and commissioning of solar cooling plants.
- Analysis of novel concepts and technologies with special emphasis on thermodynamic principles and a bibliographic review.
- Performance comparison of available simulation tools and applicability for planning and system analysis.
- Market transfer and market stimulation activities, which include information letters, workshops and training material as well a completely revised new edition of the Handbook for Solar Cooling for Planners.

Subtask A: Pre-Engineered Systems for Residential and Small Commercial Applications
(Lead Country: Austria)

The objective of Subtask A was to support measures for the development of small and medium size systems, characterized by a cooling capacity up to 20 kW and a high degree of pre-fabrication. The goal was to support development of systems that are already on a pre-engineered level what means that there is no additional effort in planning and they are ready to be connected directly to the room components by the installer.

Subtask B: Custom-Made Systems for Large Non-Residential Buildings and Industrial Applications
(Lead Country: Italy)

The objective of Subtask B was to overcome the main technology related barriers for a wider implementation of medium and large-scale systems, characterized by cooling capacities greater than 20 kW with the need of individually planning for the particular application with involvement of planning engineers. Therefore the call for tender typically includes request for single components and not for the system as a whole. The target markets are large air-conditioning and refrigeration end-users (large offices and other non-residential buildings, hotels, industry etc.).

Subtask C: Modeling and Fundamental Analysis
(Lead Country: France)

The main objectives of Subtask C were the evaluation of novel and advanced solar cooling components and concepts which were still in a state of R&D and not yet ready for installation and market introduction, the evaluation of new and already existing component models and simulation tools for different types of solar cooling systems and the thermodynamic analysis of solar cooling technologies.

Subtask D: Market Transfer Activities
(Lead Country: Italy)

The main objectives of Subtask D were the identification of mainly non technical barriers for a wide application of solar cooling technologies, the implementation of targeted promotion activities based on the collective work results, the production of dissemination material as well as the implementation of knowledge transfer measures towards the technical stakeholders and furthermore the development of (support) instruments and their provision for policy makers. One of the major results with input from work of the entire Task will be a completely revised new edition of the Handbook for Solar Cooling for Planners.

Duration

The Task was started in September 2006 and completed in December 2010.

PARTICIPATION

Overall 49 organisations (institutions and companies) from the following 12 countries participated in the Task 38 (percentage of participants noted):

Australia 2%
Austria 12%
Canada 6%
Denmark 8%
France 8%
Germany 19%
Italy 14%
Malta 2%
Mexico 2%
Portugal 2%
Spain 21%
Switzerland 4%

TASK ACCOMPLISHMENTS

The main objective of the Task 38 was the implementation of measures for an accelerated market introduction of solar air conditioning and refrigeration with a major focus on improved components and system concepts. The strong participation in the Task itself and the cooperation in the context of the successful monitoring showed the high interest of key players like innovative air-conditioning companies, research institutes, engineers, planners as well as building planners on the specific topic.

A main part of the activities within the Task was influenced by working out a survey on systems and the monitoring of installed solar air-conditioning systems.
A Task 38 survey provided a documentation of nearly 280 SAC installations in Europe and 32 installations in other continents. Solar thermally driven heating and cooling systems have reached a status of early market deployment and can provide economic solutions under particular boundary conditions. Experiences made in TASK 38 help to achieve successful plant design and operation.

Within the monitoring activities of Task 38 a unified monitoring procedure applicable for Solar Heat Driven Chiller (SDHC) as well as Desiccant Evaporative Cooling (DEC) systems has been developed. It enables a structured collection of monitoring data and defines a common evaluation methodology of the energy performance of solar assisted solar heating and cooling plants. This procedure guarantees the comparability of the monitoring results proven by its application to 14 small scale (< 20 kW cooling capacity) and 12 large-scale systems.

Subtask A: Pre-Engineered Systems for Residential and Small Commercial Applications

Major outcomes of Subtask A:

- The market overview comprises existing components and ongoing developments suitable for combined systems for heating and cooling with chilled water systems having cooling capacities less than 20 kW.
- A proposal for the definition of generic systems was developed based on the three main components: hot side subsystem, cold side subsystem and heat rejection and offers a new modular way of drawing system schemes.

- The monitoring activities of small scale experimentally and commercially installed solar heating and cooling systems have been performed successful over the Task time. Over all 14 systems have been monitored applying the “Monitoring Tool” developed in Task 38 for the evaluation of the systems.
- The experiences with existing systems are summarized in guidelines for installation and maintenance for pre-engineered systems. Additionally a survey among end-users or plant operators with the collection of their expectations regarding operation, installation and maintenance has been carried out. It is based on the results of 18 interviews in 6 different countries and represents also 8 different application types.

Figure 1: Installation at the office building of the Company SOLID in Graz, Austria (17.5 kW Yazaki chiller WFC 5). *(Source: SOLID)*

Subtask B: Subtask B: Custom-Made Systems for Large Non-Residential Buildings and Industrial Applications

Major outcomes of Subtask B:

- A survey of solar heating and cooling systems in the countries participating in Task 38 and worldwide has been worked out as far as information was accessible. Based on this overview a more detailed discussion of hydraulic schemes has been done on the base of 20 systems.
  - As support for future installations the previous experiences on control strategies were compiled on the basis of installed systems and information delivered by the Task 38 participants.
- A main part in Subtask B was the monitoring of overall 11 demo projects of large solar cooling installations. The specific report comprises the explanation of all installations as well as the presentation of the performance figures and monitoring results.
- To guarantee the comparability of the monitoring results a generally accepted evaluation procedure has been elaborated and applied to all systems within the monitoring activities of Subtask A and B.
- The online-tool “Check-list method for the selection and the success in the integration of a solar cooling system in buildings” is available on

On the website of the company TECSOL www.tecsol.fr/checklist/. It is based on the feedback of European solar cooling experiences in the framework of SHC Task 38. The method and tool has been developed to support the evaluation of the potential of using solar cooling technology in the early phase of a project.

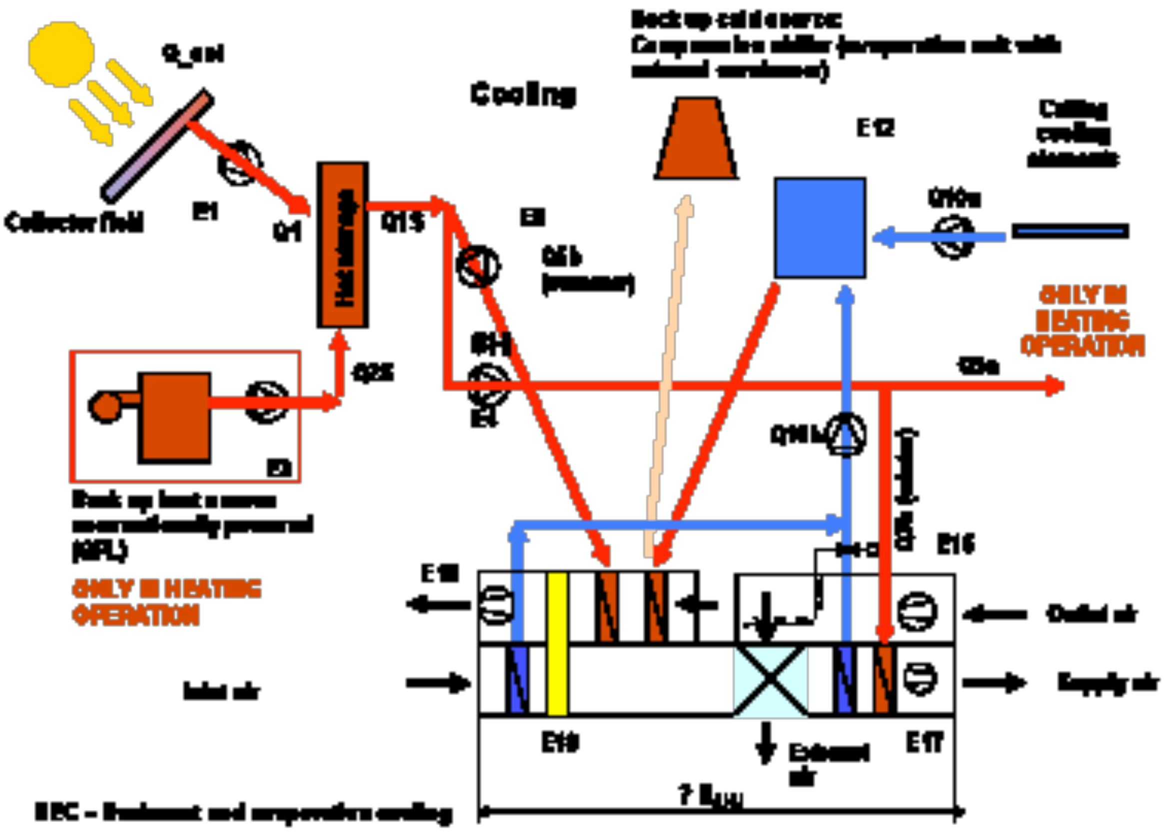


Figure 2. Application of the monitoring procedure for the example of a DEC-System. *(Source: DREAM, University of Palermo)*

Figure 3. Solar cooling installation at a winery in Tunisia.

Figure 4. Solar heating and cooling installation at the Town Hall in Gleisdorf, Austria (304 m² flat plate collectors connected to 35 kW Yazaki chiller WFC 10 and a desiccant evaporative cooling system). *(Source: AEE INTEC, Gleisdorf)*

As support for further planning of solar heating and cooling systems a detailed commissioning list has been elaborated following the different sub-systems of a SHC system and the different phases of a project. The document is explaining commissioning as a whole process and delivers various further information and links.

Subtask C: Modeling and Fundamental Analysis

Major outcomes of Subtask C:

- The survey on new solar cooling developments describing the state of the art comprises all relevant technologies: Absorption, Adsorption, Liquid desiccant systems, Solid desiccant systems, Thermo-mechanical chiller, and Steam jet chiller

- Different work has been done concerning modelling of SHC systems using different technologies (closed cycles, open cycles) using different software tools:
  - Description of simulation tools used in solar cooling - New developments in simulation tools and models and their validation (Solid desiccant cooling, Absorption chiller)
  - Benchmarks for comparison of system simulation tools – Absorption chiller and desiccant simulation comparison
- Another important area was the exergy analysis of solar cooling, its components and processes and also the evaluation of the performance of installed systems. In this context appropriate performance criteria have been elaborated which allow a comparative assessment.
- Because the question of heat rejection is of high interest for proper operation of solar cooling systems the different available technologies, their components and the electricity consumption have been analysed and evaluated.

Subtask D: Market Transfer Activities

Major outcomes of Subtask D:

- Life cycle analysis offers the possibility to investigate the impact of one technology in a specific application on the environment for its lifetime. The application of life cycle analysis to solar cooling systems and its results can offer arguments for new technologies. The activities here were the definition of a common methodology for life cycle analysis of solar cooling systems and the collection of data for the main components of both the solar cooling and the reference systems. Studies for different examples and technologies were carried out (solar driven desiccant cooling, solar driven closed adsorption chiller).
- One of the major results with input from work of the entire Task will be a new completely revised edition of the Handbook for Solar Cooling for Planners. The handbook is divided into two major parts. The first part will provide a general introduction into the components. The second part will give a more detailed insight in the various technologies and experiences in realized installations.
- With the elaboration of a Solar Cooling Position Paper a description of the state of the art and a roadmap is available. The paper consists of three main parts: The consideration of the status comprises technical maturity, energy performance, economic viability and market status. In the second part technical potentials, costs and economics as well as market opportunities are analysed. In the third part an overview is given on the different actions needed. This part comprises technology development, quality procedures and the consideration of market and policy issues. The development of the Position Paper incorporated feedback from many experts from R&D and manufacturers CEO's.
- As support for dissemination activities by participants of the Task 38 a complete version of training material comprising the wide field of solar assisted air conditioning technologies and its application was provided in four languages and has been released and uploaded to the internal Task 38 website.
- During the Task 38 several workshops and conferences on both technical and market issues related/dedicated to solar assisted air conditioning technology have been carried out and/or supported with a large number of contributions. An overview is given in Table 1.
- An e-newsletter translated into five languages (English, German, Spanish, French, Italian) is available on the website.

Table 1: Workshops and Conferences

Workshop/Conference	Place	Date
Conference "Solar Air-Conditioning and Refrigeration"	Bolzano/Italy	October 18, 2006
Workshop "Solar Air-Conditioning and Refrigeration"	Aix-les-Bains /France	April 25, 2007
Workshop "Solar Air-Conditioning and Refrigeration"	Barcelona/Spain	October 15, 2007
Conference "Sustainable Cooling Systems – Part 1: Solar Cooling"	Vienna/Austria	March 31, 2008
EUROSUN 2008	Lisbon/Portugal	October 7-10, 2008
Gleisdorf Solar 2008 with a half day block on solar cooling	Gleisdorf/Austria	September 3-5, 2008
Joint Workshop of Task 38 with IEA HPP Annex 34 "Thermally Driven Heat Pumps for Heating and Cooling"	Freiburg / Germany	April 29, 2009
3rd International Conference Solar Air-Conditioning	Palermo/Italy	September 30 – October 2, 2009
Task 38 workshop at the ASHRAE Trade Show	Orlando, Florida	January 2010
Public workshop "Solar driven cooling and air-conditioning in a Danish and world-wide perspective"	Aarhus/Denmark	April 28, 2010
EUROSUN 2010 with participation of Task 38 experts	Graz, Austria	September 29 – October 1, 2010

LINKS WITH INDUSTRY

A number of the Task experts are representing companies active either on planning and installation of solar thermal systems or manufacture of key components such as thermally driven cooling systems. In addition, many involved R&D institutes are closely co-operating with companies, mainly start-up companies, active in developing new small-scale thermally driven cooling machines (water chillers, open cycle systems). The Task also contributed to workshops addressing professionals working in the design and installation of HVAC and solar systems for buildings.

CONCLUSIONS/RECOMMENDATIONS

Task 38 was one of the largest single activities of the IEA Solar Heating & Cooling Programme in terms of participation. Overall 49 organizations from 12 countries participated in the Task – 16 research institutes, 20 universities and 13 private companies (planning and engineering offices, manufacturers and installation companies). And also the large participants at the expert meetings (in average 64) show the high interest on the addressed topic. The high quality of the reports and results and their presentation at various conferences and other events certainly contributed to the technical progress of this technology and thereby supported its market deployment.

A main activity of Task 38 was a detailed monitoring of an overall of 25 installations. 14 of these installations were in the small capacity range and aimed at supporting the development of small capacity, pre-engineered systems for application in the residential and small commercial sectors. 11 of the 25 systems are installed in large commercial buildings or provide cold to industrial processes – they represent a category of custom-made systems which are particularly designed for the special conditions of the given site and application. As a main result it was shown that systems are able to achieve significant primary energy savings in comparison to standard solutions using conventional electrically driven vapor compression systems. However, it also turned clearly out that a high quality on all project levels is needed in order to achieve these savings. A careful design, a high quality installation, a deep commissioning and an ongoing monitoring ("continued commissioning") is necessary in order to guarantee a long-term stable operation and benefits in terms of lower energy consumption and operation costs compared to standard solutions. In Task 38 various tools and concepts were developed which will be able to contribute to successful projects.

In addition many cross-cutting activities in the field of research were carried out such as an exergy analysis of solar cooling systems which may help to optimize the system design, a simulation study in which different simulation tools were compared looking at the reliability of their results and the user effort to operate them and – for the first time – an extensive life cycle analysis of solar cooling systems was made.

KEY REPORTS/PUBLICATIONS (expected publication dates included)

Reports Available on the SHC Website

Market Available Components for Systems for Solar Heating and Cooling with a Cooling Capacity < 20 kW
A technical report of subtask A

Collection of Selected Systems Schemes "Generic Systems"
A technical report of subtask A

Installation and Maintenance Guidelines (to come in 2011)
A technical report of subtask A

State of the Art on Existing Solar Heating and Cooling Systems
A technical report of subtask B

Monitored Installations and Results
(to come in 2011)
A technical report of subtask B

Monitoring Procedure (technical report describing the methodology including performance figures and performance evaluation) (to come in 2011)
A technical report of subtask B

Commissioning Guideline
A technical report of subtask B

State of the Art – Survey on New Solar Cooling Developments
A technical report of subtask C

Description of Simulation Tools Used in Solar Cooling - New Developments in Simulation Tools and Models and Their Validation (Solid desiccant cooling, Absorption chiller)
A technical report of subtask C

Benchmarks for Comparison of System Simulation Tools – Absorption Chiller Simulation Comparison
A technical report of subtask C

Benchmarks for Comparison of System Simulations tools – Desiccant Systems →
(to come in 2011)
A technical report of subtask C

Exergy Analysis of Solar Cooling Systems
A technical report of subtask C

Heat Rejection
(to come in 2011)
A technical report of subtask C

Life Cycle Assessment of Solar Cooling Systems
A technical report of subtask D

Solar cooling position paper
(to come in 2011)

Task 38 Related Presentations/Papers

Overview in World Wide Installed Solar Cooling Systems.
Sparber, W., Napolitano, A. and Melograno, P., 2nd International Conference Solar Air Conditioning, Tarragona - Spain, October 2007

Task 38 Related Presentations At The Eurosun 2008

The AC-Sun, a new concept for air conditioning
October 2008 - PDF 0.31MB - Posted: 7/17/2009
By: Minds, S. and Ellehauge, K.

Solar Energy Cools Milk
October 2008 - PDF 0.72MB - Posted: 7/17/2009
By: Ayadi, O. Doell, J.Aprile, M. Motta, M. and Núñez, T.

Monitoring of a solar desiccant cooling system in Palermo, (Italy)
First results and test planning

October 2008 - PDF 0.32MB - Posted: 7/17/2009
By: Beccali, M., Finocchiaro, P., Luna, M. and Nocke, B.

Heat rejection as a control strategy for Solar Combi+ systems
October 2008 - PDF 0.34MB - Posted: 7/17/2009
By: Besana, F., Franchini, G., Perdichizzi, A., Rodriguez, J., Sparber, W. and Witte, K.

Modelling and first experimental characterization of a sorptive heat exchanger prototype for application in a novel desiccant evaporative cooling cycle
October 2008 - PDF 0.35MB - Posted: 7/17/2009
By: Bongs, C., Morgenstern, A. and Henning, H.-M.

A sensitivity analysis of a desiccant wheel
October 2008 - PDF 0.28MB - Posted: 7/17/2009
By: Bourdoukan, P., Wurtz, E., Joubert, P. and Spérandio M.

Development and Investigation of solar cooling systems based on small-scale sorption heat pumps
October 2008 - PDF 0.45MB - Posted: 7/17/2009
By: Jakob, U. and Saulich, S.

First results of a solar-thermal liquid desiccant air conditioning concept
October 2008 - PDF 0.72MB - Posted: 7/17/2009
By: Jones, B. M. and Harrison, S. J.

Operation of a small scale ice store
October 2008 - PDF 0.37MB - Posted: 7/17/2009
By: Koller, T., Zetzsche, M., Brendel, T. and Müller-Steinhagen, H.

Comparison of control strategies of solar absorption chillers
October 2008 - PDF 0.54MB - Posted: 7/17/2009
By: Kühn, A., Corrales Ciganda, J. L. and Ziegler, F.

Test results from a latent heat storage developed for a solar heating and cooling system
October 2008 - PDF 0.91MB - Posted: 7/17/2009
By: Mehling, H., Hiebler, S., Schweigler, C., Keil, C. and Helm, M.

Coupling solar collectors and co-generation units in solar assisted heating and cooling systems
October 2008 - PDF 0.28MB - Posted: 7/17/2009
By: Napolitano, A.

Heating and cooling with a small scale solar driven adsorption chiller combined with a borehole system
October 2008 - PDF 0.48MB - Posted: 7/17/2009
By: Núñez, T., Nienborg, B. and Tiedtke, Y.

Simulation Based Optimisation of a Newly Developed System Controller for Solar Cooling and Heating Systems
October 2008 - PDF 0.9MB - Posted: 7/17/2009
By: Pietruschka, D., Jakob, U., Hanby, V. and Eicker, U.

Unified monitoring procedure and performance assessment for solar assisted heating and cooling systems
October 2008 - PDF 0.78MB - Posted: 7/17/2009
By: Sparber, W., Thuer, A., Besana, F., Streicher, W. and Henning, H.-M.

Solar cooling in the German funding program SOLARTHERMIE 2000plus
October 2008 - PDF 0.45MB - Posted: 7/17/2009
By: Wiemken, E.

Absorption chiller modelling with TRNSYS
Requirements and adaptation to the machine EAW Wegracal SE 15
October 2008 - PDF 0.26MB - Posted: 7/17/2009
By: Witte, K. T., Albers, J., Krause, M., Safarik, M., Besana, F. and Sparber, W.

Solar cooling with an ammonia/water absorption chiller

October 2008 - PDF 0.46MB - Posted: 7/17/2009
By: Zetzsche, M., Koller, T. and Müller-Steinhagen, H.

Energy and exergy analysis of advanced cycles for solar cooling
October 2008 - PDF 0.53MB - Posted: 7/17/2009
By: Marletta, L., Evola, G. and Sicurella, F.

Task 38 Related Presentations at Eurosun 2010

Ayadi. O: Improvement of Solar Sooling Plant Performance based on Simulation and Experimental Activities

Bader, T.: In-Situ Analysis and Operational Optimisation of a Solar-Driven DEC-System

Beccali M.: ODESSE: A new Tool for Simulation and Design of Solar Desiccant Cooling Systems in Energy Efficient Buildings

Bongs, C.: Simulation Tools for Solar Cooling Systems – Comparison for a Virtual Chilled Water System

Boudéhenn, F.: Dynamical studies with a semi-virtual testing approach for characterization of small scale absorption chiller

Buchholz, R.: Investigation of the Reduced Performance of a Collector Array with Direct-Flow Vacuum Tubes

Dalibard, A.: Primary energy optimisation of a solar adsorption cooling plant through dynamic simulations

Evola, G.: Description and validation of a dynamic tool for the modelling of a solar-assisted absorption cooling machine

Gantenbein, P.: Solar thermal absorption cooling - heat rejection by pulsed water spraying on a hybrid cooler

Henning, H.: Solar air-conditioning and refrigeration - achievements and challenges (invited keynote)

Jakob, U.: Solar Cooling - Green Chiller Industry Association

Jones, M.: Survey of control and configuration of solar heat driven chiller systems

Weissensteiner, Th.: Practical experience of two small scale cooling plants and cost comparison to PV driven chillers

Olsacher, N.: Solar Cooling – A Worldwide Proven Technology

Palacín, F.: Design and operational experiences of an alternative heat rejection sink for an existing absorption solar cooling system

Pietruschka, D.: Solar Cooling for Southern Climates, Double Effect Absorption Chillers with High Concentrating Collectors Versus Standard Single Effect Systems

Pink, W.: New Concepts for Solar / Thermally Driven Cooling

Riepl, M.: Solar Assisted Cooling and Heating with Multi-Stage Absorption Chiller

Sparber, W.: Practical experience on design and sizing from worldwide documented solar cooling systems

Thür, A.: Monitoring Program of Small-Scale Solar Heating and Cooling Systems within IEA-SHC Task 38 – Procedure and First Results

Vukits, M.: Solar Heating and Cooling for the City of Gleisdorf Optimisation of the Control Strategy

Wiemken, E.: Performance and Perspectives of Solar Cooling

ACTIVITIES PLANNED FOR 2011

A final presentation of the Task 38 is planned in a public workshop attached to the ExCo meeting in fall 2011 in Germany.

MEETINGS HELD IN 2010

8th Expert Meeting
April 26-27
Aarhus, Denmark

9th Expert Meeting (final meeting)
September 27-28
Graz, Austria

TASK 38 NATIONAL CONTACTS

Operating Agent
Hans-Martin Henning
Fraunhofer Institut für Solare Energiesysteme
Heidenhofstr.2
79110 Freiburg, Germany
hans-martin.henning@ise.fraunhofer.de

Leader Subtask A
Dagmar Jähnig
AEE INTEC, AEE - Institute for Sustainable Technologies
Feldgasse 19
A-8200 Gleisdorf, Austria
a.thuer@aee.at

Leader Subtask B
Wolfram Sparber
EURAC research
Viale Druso/Drususallee 1
39100 Bolzano/Bozen, Italy
wolfram.sparber@eurac.edu

Leader Subtask C
Etienne Wurtz
Institut National d'Energie Solaire
50, avenue du lac Léman BP 332
73375 Le Bourget du Lac Cedex, France
ewurt@univ-savoie.fr

Leader Subtask D
Mario Motta
Politecnico di Milano
Dip. Energetica
Piazza Leonardo da Vinci 32,
20133, Milano, Italy
mario.motta@polimi.it

Australia
Steven D. White
CSIRO Division of Energy Technology
PO Box 330
Newcastle, NSW, 2300
Stephen.D.White@csiro.au

Paul Kohlenbach
Solem Consulting
PO Box 188, Balgowlah
Newcastle, 2093
paul@solem.com.au

Wasim Saman
University of South Australia
Division of Information Technology, Engineering and the Environment
The Mawson Centre
Mawson Lakes 5095
wasim.saman@unisa.edu.au

Warwick Johnston
ClimateManagers
Melbourne
PO Box 782
Port Melbourne VIC 3207
warwick.johnston@climatemanagers.com

Jean-Luc Godillion
Energy Conservation Systems
209 Sandgate road
Albion, QLD 4010
j.godillion@escaustralia.com

Austria
Dagmar Jähnig, Alexander Thür, Erich Podesser
AEE INTEC, AEE - Institute for Sustainable Technologies
Feldgasse 19
A-8200 Gleisdorf
d.jaehnig@aee.at
a.thuer@aee.at
erich.podesser@utanet.at

Tim Selke, Marcus Jones, Anita Preisler
AIT
Business Field Sustainable Energy Systems
Giefinggasse 2
1210 Wien
tim.selke@arsenal.ac.at
don-seon.king@arsenal.ac.at

Hilbert Focke, Gerald Steinmaurer
ASIC- Austria Solar Innovation Center
Durisolstraße 7/Top 50
4600 Wels
focke.hilbert@asic.at
steinmaurer.gerald@asic.at

Horst Striessnig, Philip Ohnewein, and Christian Holter
S.O.L.I.D. Gesellschaft für Solarinstallation und Design m.b.H.

Puchstraße 85
8020 Graz
p.ohnewein@solid.at
h.striessnig@solid.at
c.holter@solid.at

Wolfgang Streicher, Harald Moser
Institute of Thermal Engineering
Graz University of Technology
Inffeldgasse 25, 8010 Graz, Austria
w.streicher@tugraz.at
harald.moser@tugraz.at

Canada

Lúcio Mesquita, Steve Harrison, and Michael Andrusiak
Queens University - Department of Mechanical and Material Engineering
Kingston, ON
mesquita@me.queensu.ca
harrison@me.queensu.ca
jones@me.queensu.ca

Denmark

Klaus Ellehauge
Ellehauge & Kildemoes
Vestergade 48H, 2.tv.
8000 Århus C
klaus.ellehauge@elle-kilde.dk

Søren Ø. Jensen, Claus S. Poulson, and Lars Reinholdt
Danish Technological Institute
Refrigeration and Heat Pump Technology
Teknologiparken
Kongsvang Allé 29
DK-8000 Aarhus C
soren.o.jensen@teknologisk.dk
claus.s.poulsen@teknologisk.dk
lars.reinholdt@teknologisk.dk

Søren Minds
AC-Sun
Rudolfsgaardsvej 19
DK-8260 Viby J
smi@ac-sun.com
Ebbe Münster, Per Alex Sørensen
PlanEnergi
Jyllandsgade 1
DK 9520 Skørpingi
em@planenergi.dk
jen@planenergi.dk
pas@planenergi.dk

France

Etienne Wurtz, Paul Bourdoukan, Nolwenn Le Pierrès
INES - Université de Savoie
BP 332 - Savoie Technolac
50 Avenue du Lac Léman
F-73377 Le Bourget du Lac
Etienne.Wurtz@univ-savoie.fr
nolwenn.le-pierres@univ-savoie.fr
paul.bourdoukan@univ-lr.fr

Nadège Chatagnon
EDF R&D
Department EnerBat
Site des Renardières - Ecuelles
77 818 Moret-sur-Loing
nadege.chatagnon@edf.fr

Daniel Mugnier, Amandine Le-Denn, Jean-Yves Quinette
TECSOL SA.
105 av Alfred Kastler - BP 90434
66 004 PERPIGNAN Cedex
daniel@tecsol.fr
amandine.le-denn@tecsol.fr
jyq@tecsol.fr

Thibaut Vitte, Monika Woloszyn
CETHIL - UCBL/INSA Lyon/CNRS
thibaut.vitte@insa-lyon.fr
monika.woloszyn@insa-lyon.fr

Michel Pons
LIMSI - CNRS
91403 Orsay Cedex
michel.pons@limsi.fr

Germany

Alexander Morgenstern, Edo Wiemken
Fraunhofer Institut für Solare Energiesysteme
Heidenhofstr.2
79110 Freiburg
alexander.morgenstern@ise.fraunhofer.de
edo.wiemken@ise.fraunhofer.de

Reiner Buchholz, Felix Ziegler
Technische Universität Berlin
Institut für Energietechnik
Marchstraße 18
D-10587 Berlin
reiner.buchholz@tu-berlin.de
felix.ziegler@tu-berlin.de

Uli Jacob
Solarnext AG
Nordstr. 10
83253 Rimsting
uli.jakob@solarnext.de

Michael Krause, Roland Heinzen
Institute of Thermal Engineering
University of Kassel
Kurt-Wolters-Str. 3
34125 Kassel
mikrause@uni-kassel.de
heinzen@uni-kassel.de

Christian Schweigler
ZAE Bayern
Walther-Meißner-Str. 6
85748 Garching
schweigler@muc.zae-bayern.de

Christian Dötsch, Clemens Pollerberg
Fraunhofer Umsicht
Osterfelder Str. 3
D-46047 Oberhausen
noe@umsicht.fhg.de

Uwe Franzke
ILK Dresden GmbH
Bertolt-Brecht-Allee 20
01309 Dresden
uwe.franzke@ilkdresden.de

Thomas Brendel, Marco Zetsche
Universität Stuttgart, Institut für Thermodynamik und Wärmetechnik (ITW)
task38@itw.uni-stuttgart.de

Tobias Bader, Christoph Trinkl
Hochschule Ingolstadt
Esplanade 10
85049 Ingolstadt
tobias.bader@fh-ingolstadt.de

Dirk Pietruschka
Solare Energiesysteme und Bauphysik
Hochschule für Technik Stuttgart
dirk.pietruschka@hft-stuttgart.de

Italy

Wolfram Sparber, Francesco Besana, Assunta Napolitano
EURAC Research
European Academy Bolzano
Viale Druso/Drususallee 1
39100 Bolzano/Bozen
wolfram.sparber@eurac.edu
francesco.besana@eurac.edu
assunta.napolitano@eurac.edu

Mario Motta, Marcello Aprile, Marco Calderoni, Michele Liziero
Politecnico di Milano
Dip. Energetica
Piazza Leonardo da Vinci 32,
20133, Milano
mario.motta@polimi.it
aprile.marcello@polimi.it
michele.liziero@polimi.it

Marco Beccali, Pietro Finocchiaro, Bettina Nocke
University of Palermo
Viale delle Scienza 9
90128 Palermo
marco.beccali@dream.unipa.it
pietro.finocchiaro@dream.unipa.it
bettina@dream.unipa.it

Sufia Jung, Andrea Cagni
OLYMP ITALIA SRL
Via Orbassano, 16
10090 Bruino, Italy
olympitalia@olympitalia.it
andrea.cagni@libero.it

Rajendra S. Adhikari
Politecnico di Milano
Department of Building Environment Sciences & Technology (BEST)
Via Garofalo 39
20133 Milano, Italy
rajendra.adhikari@polimi.it

Luigi Marletta
Universita di Catania
Dipartimento di Ingegneria Industriale e Meccanica (DIIM)
Viale A. Doria 6
95125 Catania, Italy
luigi.marletta@diim.unict.it
gevola@unict.it

Tullio Pagano
AMG Energia SpA
Via Ammiraglio Gravina 2e
Palermo, Italy
tullio.pagano@amg.pa.it

Maurizio De Lucia
Universita di Firenze (CREAR)
delucia@unifi.it

Serena Drigo, Claudia Vannoni
University of Rome La Sapienza
Dipartimento di Meccanica e aeronautica
serena.drigo@gmail.com
claudia.vannoni@gmail.com

Mexico

Roberto Best y Brown, Camilo Alberto A-rancibia Bulnes, Wilfrido Rivera Gomez Franco, and Octavio Garcia Valladares
CIE-UNAM (Centro de Investigacion en Energia
Universidad Nacional Autonoma de Mexico
rbb@cie.unam.mx
caab@cie.unam.mx
wrgf@cie.unam.mx ogv@cie.unam.mx

Portugal

João Farinha Mendes, Maria Joao Carva-lho
DER/INETI, Edificio G
Estrada do Paço do Lumiar
1649-038 Lisboa
farinha.mendes@ineti.pt
mjoao.carvalho@ineti.pt

Spain

Juan Rodriguez Santiago, Luis Angel Bujedo
Fundación CARTIF
Energy Division, Renewable Energies Area
Parque Tecnológico de Boecillo, parcela 205
47151 Boecillo, Valladolid
juarod@cartif.es
luibuj@cartif.es

Laura Sisó Miró, Dani Gonzales, and Jaume Salom
AIGUASOL ENGINYERIA
Sistemes Avançats d'Energia Solar Tèrmica SCCL
C/ Roger de Llúria, 29 3r 2a
08009 Barcelona
laura.siso@aiguasol.coop
dani.gonzales@aiguasol.coop
jaume.salom@aiguasol.coop

Marcelo Izquierdo Millán
Instituto de Ciencias de la Construcción Eduardo Torroja (CSIC)
c/ Serrano Galvache N° 4
28033 Madrid
mizquierdo@ietcc.csic.es

Pedro Juan Martínez Beltrán
Universidad Miguel Hernández
Área de Máquinas y Motores Térmicos
Dpto. Ingeniería de Sistemas Industriales
Avenida de la Universidad
s/n /Edificio Torreblanca)
03202 Elche – Alicante
pjuan.martinez@umh.es

Antonio Lecuona Neumann, Pedro Acisclo Rodríguez Aumente, and Raquel Lizarte
Universidad Carlos III de Madrid
Dpto. de Ingeniería Térmica y de Fluidos
Avda. de la Universidad 30
28911 Leganés, Madrid
lecuona@ing.uc3m.es
aument@ing.uc3m.es
rlizarte@ing.uc3m.es

Bakarne Egilegor, Maider Usabiaga
IKERLAN - Centro de investigation tecnològicas
Parque Tecnológico de Álava
Juan de la Cierva 1
01510 Miñano
begilegor@ikerlan.es
musabiaga@ikerlan.es

Susana López, Arrate Marcaide
Centro Tecnológico Tekniker
Renewable Energy Unit
Apdo. 44
Avda. Otaola 20
20600 Eibar· Guipúzcoa
slopez@tekniker.es
amarcaide@tekniker.es

José A. Ferrer Tevar and Ester Rojas
CIEMAT
Unidad de Eficiencia Energética en la Edificatión
Avenida Complutense 22
28040 Madrid
ja.ferrer@ciemat.es

Maria J. Jiménez Taboada
CIEMAT
Unidad de Eficiencia Energética en la Edificatión
Plataforma Solar de Almería
04200 Tabernas, Almería
mjose.jimenez@psa.es

Marcos Lucena Martin
INTA
Ctra. San Juan del Puerto-Matalascañas km. 34
21130 Mazagón,Huelva
lucenamm@inta.es

Amandine Gal
Acciona Infraestructuras
Departamento de Investigación,
Desarrollo e Innovación
Polígono Industrial de Alcobendas
C/Valportillo II, 8
28108 Alcobendas (MADRID)
amandgal@acciona.es

Switzerland

Jacques Bony, Catherine Hildbrand, Stéphane Citherlet
HEIG-VD - School of Business and Engineering
Laboratory of Solar Energetics and Building Physics (LESBAT)
Route de Cheseaux 1
CH - 1400 Yverdon-les-Bains
stephane.citherlet@heig-vd.ch
catherine.hildbrand@heig-vd.ch
jacques.bony@heig-vd.ch

Andreas Luzzi, Paul Gantenbein
Institut für Solartechnik SPF
Hochschule für Technik Rapperswil HSR
Oberseestrasse 10
CH-8640 Rapperswil
andreas.luzzi@solarenergy.ch
paul.gantenbein@solarenergy.ch

Carsten Hindenburg
Hindenburg Consulting
Hauptstr. 28
CH- 4469 Anwil
ch@hindenburg-consulting.com

Task 39

Polymeric Materials for Solar Thermal Applications

Michael Köhl
Fraunhofer ISE
Operating Agent for the Projektträger Jülich

TASK DESCRIPTION

The objective of Task 39 is the assessment of the applicability and the cost-reduction potential by using polymeric materials and polymer based novel designs of suitable solar thermal systems and to promote increased confidence in the use of these products by developing and applying appropriate methods for assessment of durability and reliability.

These goals will be achieved by either less expensive materials or less expensive manufacturing processes.

The Task's objectives are being achieved in the following Subtasks:

Subtask A:	Information (Norway, Michaela Meir)
Subtask B:	Collectors (France, Philippe Papillon)
Subtask C:	Materials (Austria, Gernot Wallner)

Subtask A: Information

The objective of Subtask A is to collect, create and disseminate information about the application of polymeric materials in solar thermal systems and their figures or merits, especially in terms of cost/performance ratios for an acceptable lifetime, in order to increase the penetration of good applications into the market.

The production of a periodical newsletter, targeted at the solar- and polymer industry, and the preparation and revision of an electronic or printed handbook on polymeric materials in solar thermal applications are to be main results of this Subtask.

Activities

- Updating of the state-of-the-art overview of existing applications of polymeric materials in solar thermal systems and other relevant industry sectors.
- Performance of two case studies, where a total cost accounting approach is adopted, for assessment of suitability of using polymeric materials in solar thermal applications.
- Investigation of standards, regulations and guidelines with regard to the applications of polymeric materials in solar thermal systems and building integration.
- Extension of the database consisting of showcases where solar collectors using mostly polymeric materials have been successfully integrated into the architecture.
- Dissemination of information of the work and results in all Subtasks to a wide audience.

These activities will be carried out in five projects:

- A1: State of the art: polymeric materials in solar thermal applications
- A2: Task force on total cost accounting approach
- A3: Task force on standards, regulations and guidelines
- A4: Database of successful architectural integration
- A5: Dissemination of information

Subtask B: Collectors

Objectives

Based on the results of the first phase of this subtask, the objectives for the extension phase are focused on the development of:

- new collectors, made completely or partly with polymeric materials, with a profitable cost of ownerships,
- innovative concepts based on polymeric materials (integrated collector storage, thermo-syphon systems) or adapted to specific requirements of polymeric collectors (overheating protection, pressure, etc.), and
- other components of a solar thermal system (piping, fitting, storage, drain back vessel, etc) that could benefit of polymeric materials or processes.

Activities

Based on the updated state-of-the-art from Subtask A, studies and development of new collectors, systems and components will be produced in order to show the feasibility, performance, durability and cost savings. To achieve the objectives, the activities will be carried out in 3 projects:

B1: Collector
B2: System
B3: Others components

Subtask C: Materials

As shown in Phase I of Task 39, polymer engineering and science offer great potential for new products in solar thermal systems, which simultaneously fulfill technological and environmental objectives as well as social needs. The major achievements within Phase I of task 39 concerned the significant improvement in the long-term stability of an extruded polymer collector as well as the realization of a polypropylene based modular storage tank. Furthermore, a variety of novel polymeric material grades and components for solar-thermal systems (e.g., spectrally selective coatings with improved performance and commercial availability, injection-molded installation board, extruded spacers for the fixing of an absorber in the collector frame, thermoformed casings for collectors based on polycarbonate blends, polymeric foams with enhanced service temperature) were realized.

The final product performance, functionality, durability and costs not only depend on the type of the polymeric material used, but also on many other factors related to product design, processing and production. As evidenced in Phase I of Task 39, the different components in solar thermal systems have to fulfill a complex material property profile which can be provided only by multi-functional polymer compounds. The classical differentiation between structural (load-carrying) and functional polymeric materials is therefore not suitable in context with the application of plastics in solar thermal systems.

Objectives

- Further development and investigation of multi-functional polymeric materials for various components in solar thermal systems considering different plant types and climate zones.
- Evaluation of polymer processing methods for the production of specimen and components with special focus up to the sub-component level (e.g., multi-layer films and sheets). Full components will be developed in Subtask B.
- Development of testing and characterization methods and modeling tools for the application-oriented assessment of the performance and durability.

Activities

- Formulation of multi-functional polymeric materials for various components of solar thermal systems (e.g., absorber, insulation and frame of a collector, storage tank components). The considered polymeric material classes will include thermoplastics (i.e., melt processable materials), elastomers (i.e., chemically cross-linked soft materials) and thermosets (i.e., chemically cross-linked stiff materials).
- Compounding of polymeric materials considering a variety of functional fillers and additives allowing for improved processability and enhanced performance.
- Production of specimen and sub-components by applying various mass production processing technologies (e.g., injection molding, compression molding, extrusion, coating technologies, lamination and joining technologies).
- Establishment of a toolbox for the quality testing of polymeric materials for specific applications in solar thermal systems considering the various material states along the value creation chain.
- Implementation and application of analytical and technical methods for the characterization of properties, long-term

behaviour and relevant aging and degradation phenomena.

- Establishment of micro-structure/ property/processing/performance relationships.

Duration

The SHC Executive Committee agreed on a 4-year extension of the Task. The Task was initiated on October 1, 2006 and will be completed on September 30, 2014.

ACTIVITIES DURING 2010

Taskforce "How to Make Solar Thermal Systems More Desirable"

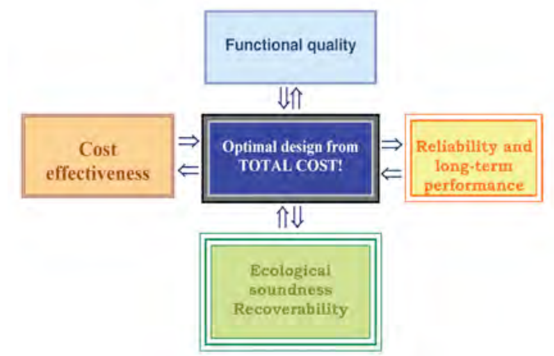
Visually appealing solar heating systems: One of the outcomes of Task 39 is a database, which includes projects where not only function but also aesthetics and architectural integration is the focus. A small group of 3-4 experts (architects and solar thermal engineers) has evaluated the incoming projects for the database. The address of the data base is http://www.iea-shc.org/task39/projects/default.aspx.

Dissemination and Information

The experts file an electronic newsletter, which is prepared from the presentations at every Task Experts meeting. The newsletters are distributed to the Task participants, different contact lists and can be downloaded from the public Task 39 website: http://www.iea-shc.org/task39/newsletters/index.html.

Eleven contributions related to Task 39 were presented at the EuroSun 2010 Conference. The abstracts are included in the newsletters.

Total Cost Accounting For Material Selection In Product Design



To meet the requirements on sufficient functional capability, service reliability and minimum environmental impact and cost in design of a functional unit of a product, a total cost accounting approach may favourably be adopted. Most appropriate product design alternative is the one with lowest total cost, the latter determined by the sum of production cost, cost associated with initial non-ideal function or performance during service, operation and maintenance cost, probable cost of failures and damage during use, end of life cost, and probable cost associated with ecological damage. The total cost accounting approach has successfully been adopted for material selection in many areas of application, such as in design of solar absorber coatings, use of lightweight materials in automotives, and in design of more sustainable product element life cycles related to materials for windings in electric transformers. By adopting a total cost accounting approach to solar collector design within the framework of some selected case studies, the suitability of using polymeric materials relative to more traditional materials would be possible to assess in an illustrative way. The main advantage of the total cost accounting approach is the holistic view point taking into account not only functional quality, cost effectiveness, reliability, and long-term performance of a particular design alternative of a functional unit but also its environmental performance aspect related to ecological soundness and recoverability.

Handbook: Polymeric Materials for Solar Thermal Applications

The table of contents was slightly revised. Drafts of nearly all subsections have been already prepared for reviewing.
Preliminary table of content:

Subtask B: Solar Thermal Collectors


Within a German research project financed by the Ministry of Environment (BMU), a new concept for storing solar energy in residential buildings has been investigated. Since 2009, a product is commercially available by FSAVE Solartechnik GmbH, a spin-off of Kassel University. The so-called FLEXSAVE VARIO (picture below, right) is a heat storage that can be easily installed into existing buildings. An inner polymeric liner that is welded on-site of PP-H is used. Storage volumes from 2 to 100 m^3 are available. Since „Each cellar is different“ (FSAVE), these storages are fully customized. At the INTERSOLAR exhibition in Munich this year, FSAVE Solartechnik won the INTERSOLAR AWARD 2010 in the category “solar thermal technology”.

Polymeric Solar Collectors: Field testing of a State-of-the-Art System

A parabolic trough collector mainly made from polymer materials used for building up the trough. All major parts like the parabolic trough, the support and most of the smaller components are made out of polyamide, polyoxymethylene and polyvinylchloride. The reflector is made from MIRO®.

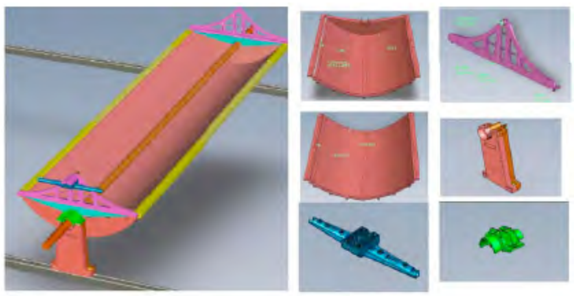


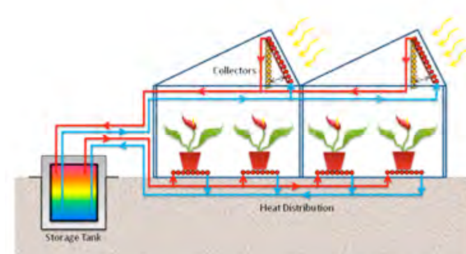
Figure 1. Sketches of the collector parts.

The first performance measurements conducted at the Institute of Thermo-dynamic and Thermal Engineering (ITW) of University Stuttgart showed very promising results. In the next development phase the stainless steel absorber will be replaced by a copper absorber with selective black chrome coating. The concentration ratio of approx. 5 allows for temperatures of more than 120°C with reasonable collector efficiency.

The production of the Aventa Solar collector has started, and the first pilot and demonstration projects are in operation. The first solar collector model is designed as a modular building element, applicable as facade elements or roof covers. The absorber is an extruded twin wall sheet in high temperature resistant PPS delivered by Chevron Phillips Chemicals, closed by means of molded en caps that are welded to the sheet. The transparent cover is a twin wall PC sheet, and the two layers are fixed together by means of aluminum profiles.

One of the main arguments for introduction of polymer materials in solar collectors is the potential for reducing costs due to different processing and manufacturing methods compared to conventional flat plate collectors. Aventa aims to reduce the processing cost by introduction of a new extrusion die enabling simultaneous extrusion of three absorbers. The new triple die is under construction.

The market acceptance of the product is depending on a good match between the collector design and the building industry. The mounting should be at least as simple and cost effective as the mounting of those elements that are replaced by the collector, and should be managed with tools familiar to the builders. A new profile concept has been designed in order to simplify the mounting and approach wishes and opinions from architects. The cooperation with the building industry has recently got a major step forward since the largest Norwegian housing company, OBOS, is engaged as a



significant shareholder in Aventa AS. OBOS has decided to create two identical passive houses (figure above) one with an air–water heat pump, the other with an Aventa solar thermal system. The two houses will be thoroughly monitored and the target is to declare a winner based on energy performance, costs and other factor that determine how well the systems are adapted to the market requests.

HELIOAGRO - The main purpose of a greenhouse is to create and maintain a controlled artificial environment that will favor the crop production with the maximum profit. Late increase on fuel prices, together with colder than normal seasons, make heating costs a significant burden on greenhouse operations. Therefore, the use of renewed energy systems, namely solar thermal systems, to control the inner environment of agricultural greenhouses becomes an economical and technological topic of unquestionable interest. Preliminary calculations on the possibility of using a solar thermal system to control the climate environment of a greenhouse show that, in certain climate conditions, a solar greenhouse can collect sufficient solar energy to feed, at least, another standard thermally optimized greenhouse of the same size. The implementation of this project, which is based on Portuguese Utility Model nº10218 – "Thermal Solar System for Collection, Storage and Distribution of Heat at Low Temperature", considers the construction of a prototype and, later, of a larger industrial greenhouse, to verify the technological and economical viability of the patented idea.

Subtask C: Materials

Summary and outlook on spectrally selective coatings for polymeric absorbers Polymeric solar absorbers are suitable for solar thermal collector applications without extended modification because the solar radiation absorbing phase (i.e. black or coloured pigments), UV stabilizers and other surface modifiers (i.e., antisoiling additives), could be relatively easy to incorporate into the polymer itself before the extrusion process is done. At least for polymers with sufficiently high thermal stability (> 200°C) (for example PPS used by AVENTA), the application of spectrally selective coatings looks reasonable in order to enhance their light-to-heat conversion efficiency. Nowadays, PVD coatings dominate the market for metallic absorbers but their application on polymeric absorbers has not yet been realized mainly due to the need for additional metallic layers serving as a low emitting substrate for the subsequent deposition of Thickness Spectrally Selective cermet coatings. In contrast, Thickness Insensitive Spectrally Selective (TISS) paint coatings represent a much better option because the coatings' thickness does not need to be controlled. Moreover, they are thick (> 20 μm), mechanically robust and can be made in different colors.

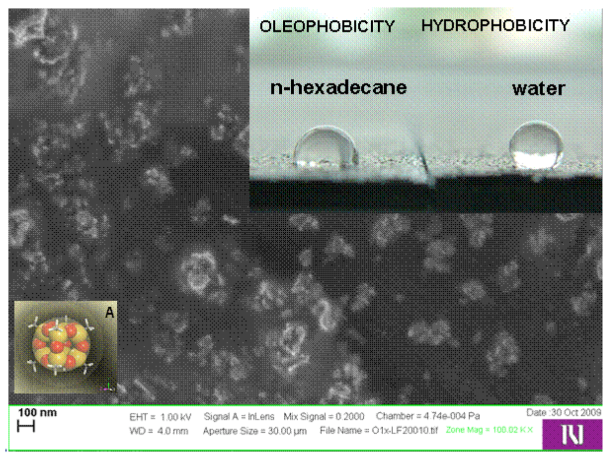


Figure 2. SEM micrograph of the surface of TISS paint coatings with separated pigment particles (~300 nm) achieved by using a dispersant based on fully condensed alkyltrialkoxy silane leading to molecules with a polyhedral structure as shown in (A). A structurally similar additive added to the paint imparts low water and oil contact angles to the coating, i.e. anti-soiling properties.

In general, they also adhere excellently to most common polymers. The first generation of coloured TISS paint coatings, which were developed within the frame of a SOLABS EU project (2002-2006) (leader Michael Koehl) exhibit moderate spectral selectivity ($\alpha_S \approx 0.90$, $\varepsilon_T \approx 0.40$, black) and variety of colour shades but these lack anti-soiling properties (low contact angles for water and oils). A new generation of coloured TISS paint coatings have been developed within the framework of Task 39 with higher selectivity ($\alpha_s \approx 0.9$ (black) and $\varepsilon_T \approx 0.25$) achieved by the use of silane based dispersants for pigments in the corresponding paints. Silane dispersants modified the pigment surface making them compatible with the paint polymeric binder and enabling the deposition of coatings that consisted of finely ground and uniformly distributed pigment particles. Also based on silane technology, an antisoiling TISS paint coating was prepared as described in Fig. 5.

Researchers at Fraunhofer ISE analyzed the aging behavior of three different polymeric materials (PPS, PPE-PS and PP with graphite) for solar thermal applications. Accelerated aging tests have been performed in climatic cabinets and solar simulators. The variation of UV irradiation, temperature and humidity allows analyzing the effects of defined combinations of these factors with Raman Microscopy and Atomic Force Microscopy (AFM).

The weathering of PPS at 85°C and UV irradiation leads to strong blooming effects as can be seen in Fig. 3. After 250h the surface area increases by approximately 17% and the Root Mean Square value by 103%. These quantitative values based on AFM measurements make trends and time dependences visible and support the interpretation of the qualitative surface images. This leads together with Raman Spectroscopic measurements to a broad understanding of materials degradation and durability.

Photovoltaic (PV) modules are designed to have a service lifetime of more than 20 years. It is hard to follow suitable degradation indicators during service life testing with sufficient accuracy for comparison with real outdoor aging during operation. Often the polymeric encapsulation material, mostly ethylene vinyl acetate (EVA), shows degradation effects. The detection of small changes of the material in a non-destructive manner helps to follow the changes over time.

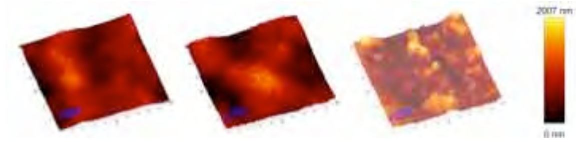


Figure 3. AFM topography images of PPS exposed to heat (85ºC) and UV irradiation. The surface topography shows significant changes during the exporsure tests. Strong blooming can be seen after 125 h (middle) and 250 h (right) shows up which is not found at the reference (left).

We started our work with small model PV modules with crystalline Si-wafers and different back sheet materials, which were analyzed after accelerated indoor aging. Systematic spectral luminescence studies of polymer degradation of EVA were carried out. The laminated test modules were exposed to ultraviolet radiation (UV) or aged under high moisture conditions (85% r.h./85°C). We found characteristic differences in polymer luminescence for the two ageing procedures.

MEETINGS IN 2010

8th Experts Meeting
April 18-20
Chambery, France

9th Experts Meeting
September 27 – 28
Blumau, Austria

MEETINGS PLANNED FOR 2011

10th Experts Meeting
May, 19-20 **11th Experts Meeting**
Slovenia

11th Experts Meeting
September 19-20
Lisbon, Portugal

TASK 39 NATIONAL CONTACTS

Operating Agent
Michael Köhl
Fraunhofer Institute for Solar Energy Systems ISE
Dept. Thermal Systems and Buildings
Heidenhofstr. 2,
79110 Freiburg, GERMANY
michael.koehl@ise.fraunhofer.de

Austria
Robert Hausner
AEE - Institut für Nachhaltige Technologien
Feldgasse 19
A-8200 Gleisdorf
r.hausner@aee.at
http://www.aee-intec.at

Christoph Zauner
Austrian Institute for Technology
Österreichisches Forschungs- und Prüfzentrum Arsenal Ges.m.b.H.
Giefinggasse 2
A-1210 Wien
christoph.zauner@ ait.ac.at

Katharina Resch
Institute of Materials Science and Testing of Plastics at University of Leoben
Franz-Josef-Straße 18
A-8700 Leoben
katharina.resch@unileoben.ac.at

Gernot Wallner
Johannes Kepler University Linz (JKU)
Institute of Polymeric Materials and Testing
Science Park, Altenberger Strasse 69
A-4040 Linz
gernot.wallner@jku.at

France
Philippe Papillon
CEA INES
Recherche, Développement et Innovation Industrielle, BP 332
50, avenue du Lac Léman
73377 Le Bourget du Lac
philippe.papillon@cea.fr
http://www.cea.fr/
http://www.ines-solaire.fr/

Germany
Trinkl Christoph
Fachhochschule Ingolstadt
Kompetenzzentrum Solartechnik
Esplanade 10
D-85049 Ingolstadt
trinkl@fh-ingolstadt.de>
http://www.solartechnik-ingolstadt.de

Helmut Vogel
University of Applied Sciences Osnabrück
P.O. Box 1940
D-49009 Osnabrück
h.vogel@fh-osnabrück.de
http://www.fh-osnabrueck.de/

Karl-Anders Weiss and Markus Heck
Fraunhofer Institute for Solar Energy Systems
Dept. Thermal Systems and Buildings
Heidenhofstr. 2,
79110 Freiburg
karl-anders.weiss@ise.fraunhofer.de
markus.heck@ise.fraunhofer.de
http://www.ise.fraunhofer.de

Claudius Wilhelms and Klaus Vajen
Universität Kassel
Mönchebergstraße 19
34109 Kassel
wilhelms@uni-kassel.de
vajen@uni-kassel.de
www.uni-kassel.de

Stephan Fischer
University Stuttgart, ITW
Pfaffenwaldring 6
D-70550 Stuttgart, GERMANY
fischer@itw-stuttgart.de
ochs@uni.itw-stuttgart.de
http://www.itw.uni-stuttgart.de

Norway
Michaela Meir and John Rekstad
University of Oslo
Department of Physics
PO Box 1048, Blindern
N-0316 Oslo
mmeir@fys.uio.no

john.rekstad@fys.uio.no
http://www.physics.uio.no/energy

Portugal

Clarisse Nunes and Manuel Lopes Prates
Instituto de Technologias Energeticas
Department de Energias Renovavaeis
Estrada do Paço do Lumiar 22
1649-038 Lisboa
lopes.prates@ineti.pt
http://www.ineti.pt

Slovenia (observer)

Boris Orel
National Institute of Chemistry Slovenia
Hajdrihova 19
PO Box 660
SI-1001 Ljubljana
boris.orel@ki.si
http://www.ki.si/

Sweden

Kenneth Moeller
SP Swedish National Testing and Research Institute
Box 857
SE-501 15 Borås
kenneth.moller@sp.se
http://www.sp.se

Bo Carlsson
Linnaeus University
School of Natural Science
39182 Kalmar
Bo.Carlsson@lnu.se

Switzerland

Stefan Brunold
Institut für Solartechnik SPF
Hochschule für Technik Rapperswil HSR
Oberseestrasse 10
CH-8640 Rapperswil
stefan.brunold@solarenergy.ch
http://www.solarenergy.ch

United States

Jay Burch
NRELNational Center for Photovoltaics
National Renewable Energy Laboratory
1617 Cole Boulevard, MS-3214
Golden, CO 80401
jay.burch@nrel.gov

Mike Rubio
FAFCO
435 Otterson Drive
Chico, CA 95928-8207
mrubio@fafco.com
http://www.fafco.com/

Susan Mantell
Department of Mechanical Engineering
University of Minnesota
111 Church St.SE, Rm 1100
Minneapolis, MN 55455
smantell@me.umn.edu

Task 40

Towards Net Zero Energy Solar Buildings

Josef Ayoub
CanmetENERGY
Operating Agent for Natural Resources Canada

TASK DESCRIPTION

Energy use in buildings worldwide accounts for over 40% of primary energy use and 24% of greenhouse gas emissions. Energy use and emissions include both direct, on site use of fossil-fuels and indirect use from electricity, district heating / cooling systems and embodied energy in construction materials. Several International Energy Agency (IEA) countries have adopted a vision of so-called 'net zero energy buildings' as long-term goal of their energy policies. However, what is missing is a clear definition and international agreement on the measures of building performance that could inform 'zero energy' building policies, programmes and industry adoption around the world.

Objective

The objective of this joint Task with the IEA ECBCS Programme (Annex 52) is to study current net-zero, near net-zero and very low energy buildings and to develop a common understanding, a harmonized international definitions framework, tools, innovative solutions and industry guidelines. A primary means of achieving this objective is to document and propose practical NZEB demonstration projects, with convincing architectural quality. These exemplars and the supporting sourcebook, guidelines and tools are viewed as keys to industry adoption. These projects aim to equalize their small annual energy needs, cost-effectively, through building integrated heating/cooling systems, power generation and interactions with utilities.

The Task will build upon recent industry experiences with net-zero and low energy solar buildings and the most recent developments in whole building integrated design and operation. The joint international research and demonstration activity will address concerns of comparability of performance calculations between building types and communities for different climates in participating countries. The goal is solution sets that are attractive for broad industry adoption.

Scope

The scope includes major building types (residential and non-residential), new and existing, for the climatic zones represented by the participating countries. The work will be linked to national activities and will focus on individual buildings, clusters of buildings and small settlements. The work will be based on analysis of existing examples that leads to the development of innovative solutions to be incorporated into national demonstration buildings.

The objectives shall be achieved in the following Subtasks.

Subtask A: Definitions & Implications

(Subtask Leaders: Karsten Voss, Germany and Assunta Napolitano, Italy)

Activity A1: NZEB definitions framework
Activity A2: Monitoring, verification and compliance guide
Activity A3: Grid interactions

The objective of Subtask A is to establish an internationally agreed understanding on NZEBs based on a common methodology. The Participants shall achieve this objective by the following activities:

- The review and analysis of existing NZEB definitions and data (site/source energy, emissions, exergy, costs, etc.) with respect to the demand and the supply side;
- A study of grid interaction (power/ heating/cooling) and time dependent energy mismatch analysis.
- The development of a harmonized international definition framework for the NZEB concept considering large-scale implications, exergy and cred-

its for grid interaction (power/heating/cooling).
- The development of a monitoring, verification and compliance guide for checking the annual balance in practice (energy, emissions and costs) harmonized with the definition.

Subtask B: Design Processes & Tools

(Subtask Leaders: Adam Hirsch, Paul Torcellini USA and Andreas Athienitis, Canada)

Activity B1: Processes and tools
Activity B2: Pre-concept design, feasibility tools
Activity B3: Tools guide and worked examples

Subtask B aims to identify and refine design approaches and tools to support industry adoption. The Participants shall achieve this objective by the following activities:

- Documenting processes and tools currently being used to design NZEBs and under development by participating countries.
- Assessing gaps, needs and problems, considering the work of Subtask A and Subtask C, and inform simulation engine and detailed design tools developers of priorities for NZEBs.
- The development and testing of design approaches and simplified NZEB tools or interfaces (e.g., spreadsheet or web-based method) linked to Subtask C Solution Sets to support integration of NZEB technologies and architecture at the early design stage.

Subtask C: Solution Sets (Design, Engineering, Technologies)

(Subtask Leaders: Michael Donn, New Zealand and François Garde, France)

Activity C1: NZEB STC Database
Activity C2: Analysis Matrix
Activity C3: Research Analysis of Themes Undertaken
Activity C4: Subtask C Source Book

The objectives of this Subtask are to develop and test innovative, whole building net-zero solution sets for cold, moderate and hot climates with exemplary architecture and technologies that would be the basis for demonstration projects and international collaboration. The Participants shall achieve these objectives by the following activities:

- Documenting and analyzing current NZEBs designs and technologies, benchmarking with near NZEBs and other very low energy buildings (new and existing), for cold, moderate and hot climates considering sustainability, economy and future prospects using a projects database, literature review and practitioner input (workshops).
- Developing and assessing case studies and demonstration projects in close cooperation with practitioners.
- Investigating advanced integrated design concepts and technologies in support of the case studies, demonstration projects and solution sets .
- Developing NZEB solution sets and guidelines with respect to building types and climate and to document design options in terms of market application and CO2 implications.

Subtask D: Dissemination & Outreach

(Operating Agent and Subtask Leaders)

Activity D1: NZEB web page
Activity D2: Reports production, Source book(s): Vols. 1, 2 and 3
Activity D3: Education network for PhD students and summer schools
Activity D4: Outreach (conferences, seminars, workshops etc.)

The objective of the dissemination activity is to support knowledge transfer and market adoption of NZEBs on a national and international level. Subtask leaders will be responsible for the coordination of the individual contributions of Subtask participants and for coordination with the other Subtasks where a combined output is planned. The Participants shall achieve the objectives by the following activities:

- Establishing an NZEB web page, within the IEA SHC/ECBCS Programmes' framework, and a database that can be expanded and updated with the latest projects and experiences.
- Producing a NZEB source book including example buildings for investigated building types and climates.
- Transferring the Task outputs to national policy groups, industry associations, utilities, academia and funding programs.
- Establishing an education network, summer school and contributions to the Solar Decathlon and similar student activities.
- Workshops, articles and features in magazines to stimulate market adoption.

Duration
This Task was initiated on October 1, 2008 and remains in force until September 30, 2013.

ACTIVITIES DURING 2010

Completed 13 technical Task papers of which 12 were presented (oral and/or poster) at EuroSun 2010, Graz, Austria (October 2010) and one was presented at the Renewable Energy 2010 (joint with the 4th ISES), Yokohama, Japan (July 2010).

Subtasks work proceeding as per work plans.

Initiated planning for the Task-led PhD summer workshop on net-zero energy solar buildings (theory, modeling and design).

Initiated negotiations for publication of Volume 1 of the Source Book in German-language initially and to be followed by and English version.

Drafted table of contents of volume 2 of the source book.

Held two industry/public workshops in conjunction with Task and SHC Executive Committee meetings.

Continuing to strengthen links to industry by participating in the Buildings and Appliances Task Force of the Asia-Pacific Partnership "Net-Zero Energy Homes" project.

18 countries confirmed participation and National Experts seeded by both the ECBCS and SHC.

Continually upgrading the Task File Sharing System and the Task public website.

Developed a Task brochure for information dissemination (can be downloadable from the Task web page).

ACTIVITIES PLANNED FOR 2011

PhD summer workshop to be held, in conjunction with the ASHRAE summer conference June 20-25, Montreal, Canada

Publication of Volume 1 of the Source Book in German language. Begin translation into English of the Volume 1 of the Source Book.

Finalize final drafts of the two technical reports from Subtask A.

Draft the Table of Contents of Volumes 2 and possibly 3 of the Source Book. Participate in public dissemination activities as opportunities arise.

Conduct at least one Industry/public workshops in conjunction with the 6th Experts Group Meeting in Basel, Switzerland.

Draft Technical report on Design Tools Benchmarking.

Submit at least two technical papers from the Task to the ASHRAE conference in Montreal.

Continue to update Task website.

REPORTS PUBLISHED IN 2010

There were 12 (#1-12) technical papers published delineating the work accomplished to date within the Task/Annex submitted to the EuroSun 2010 Conference that was held in Graz, Austria, September 28 - October 1, 2010, and another technical paper (#13) submitted to the Renewable Energy 2010 (joint with the 4th ISES) Conference, June 27-July 2 in Yokohama, Japan.

Subtask A

1. "Load Matching and Grid Interaction of Net Zero Energy Buildings (K. Voss et. al.)
2. "Net Zero Energy Buildings: Calculation Methods and input Variables - An international View" (J. Bourrelle et .al.)
3. "Criteria for Definition of Net Zero Energy Buildings" (I. Sartori et .al.)
4. "Comfort and Energy Performance Recommendations for Net Zero Energy Buildings" (I. Sartori et. al).

Subtask B

5. "Design, Optimisation and Modelling Issues of Net-Zero Energy Solar Buildings (A. Athienitis et. al.)
6. "Applying A Design Methodology for a Net Zero Energy House to Evaluate Design Processes and Tools" (W. O'Brien, et. al.)
7. "Solar 2002: A Belgian Pilot Project for Zero Energy Buildings" (R. Klein et. al.)
8. "Design Optimisation Methodologies for a Near Net Zero Energy Demonstration Home" (S. Bucking et. al.)

Subtask C

9. "The Road Towards "Zero Energy" in Buildings: Lessons Learned from The Solar XXI Building in Portugal" (L. Aelenei et. al.)
10. "Net Zero Energy Solar Buildings: An Overview and Analysis on Worldwide Building Projects" (E. Musall et. al.)
11. "Net Zero Energy Buildings in France: From Design Studies to Energy Monitoring - A State of the Art review" (A. Lenoir et. al.)
12. "BOLIG+ - an Energy Neutral Multifamily Building" (K. Wittchen et. al)
13. "Impact of the Zero Energy Mass Custom Home Mission to Japan on Industry Education Toward Commercialisation" (M. Noguchi and Jun-Tae Kim.)

All of these papers are posted for free downloading from the Task website. http://www.iea-shc.org/task40/

Technical Reports in progress:

1. "Survey of Current Practices for checking balances in Net ZEB Projects" by Assunta Napolitano and Roberto Lollini. A Report of Subtask A (A2). Draft form.
2. "Zero Energy Building definition - A Literature Review" by Anna Joanna Marszal and Per Heiselberg. A Report of Subtask A (A1).). Draft form.

MEETINGS IN 2010

3rd Experts Meeting
May 5 – 7
Ile de la Reunion, France

4th Experts Meeting
September 27 – 29
Graz, Austria
(in conjunction with EUROSUN 2010)

MEETINGS PLANNED FOR 2011

5th Experts Meeting
April 4 - 6, 2011
Golden, Colorado, USA

6th Experts Meeting
October 5 - 7, 2011
Basel, Switzerland

SHC TASK 40/ECBCS ANNEX 52
NATIONAL CONTACTS

Operating Agent
Josef Ayoub
Senior Planning Advisor, Energy S&T
CanmetENERGY/Natural Resources Canada/ Government of Canada
1615 Lionel-Boulet Blvd, P.O. Box 4800
Varennes, Québec
Canada J3X 1S6
Phone: + (1) 450-652-1981
Fax: + (1) 450- 652-5177
josef.ayoub@rncan-nrcan.gc.ca
Web:
http://www.canmetenergy.nrcan.gc.ca

Subtask A Leaders
Assunta Napolitano
EURAC Research
Insitute for Renewable Energy
Viale Druso n°1,
39100 Bozen/Bolzano
Italy
Phone: +39 0471 055 651
Fax +39 0471 055 699
assunta.napolitano@eurac.edu

Karsten Voss
Bergische Universität Wuppertal
Haspeler Straße 27
42285 Wuppertal
Germany
Phone: 0049 (0)202 439 4094
Fax: 0049 (0)202 439 4296
kvoss@uni-wuppertal.de

Subtask B Leaders
Andreas Athienitis
Concordia University (Solar Buildings Research Network)
1455 Maisonneuve W., Montreal
Quebec, H3G1M8
Canada
Phone: +1 514-848-2424 Ext. 8791
Fax: +1 514-848-7965
aathieni@encs.concordia.ca

Paul Torcellini
National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, Colorado 80401 -3305
United States
Phone: +1 303-384-7528
Fax: +1 303-384-7540
paul_torcellini@nrel.gov

Adam Hirsch
National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, Colorado 80401-3305
United States
Phone: + 303-384-7874fax
Fax +: 303-384-7540
adam.hirsch@nrel.gov

Subtask C Leaders
Michael Donn
Centre for Building Performance Research
Victoria University
PO Box 600
Wellington
New Zealand
Phone: +6444636221
Mobile: +6421611280
michael.donn@vuw.ac.nz

François Garde
Université de la Réunion
Faculty of Humanities and the Environment
Sciences Building and Environment
15, avenue René Cassin
Saint Denis, Ile de la Réunion, 97715
France
Phone: +262 (0)262 96 28 90
Fax: +262 (0)262 96 28 99
garde@univ-reunion.fr

Austria
Karl Höfler, Sonja Geier
Department for Sustainable Buildings
AEE INTEC
AEE Institute for Sustainable Technologies
Feldgasse 19
A-8200 Gleisdorf
k.hoefler@aee.at
s.geier@aee.at
http://www.aee-intec.at/index.php?lang=en

Werner Nussmüller
Nussmüller Architekten ZT GmbH
Zinzendorfg. 1
8010 Graz
buero@nussmueller.at
http://www.nussmueller.at/aktuelles.php

Belgium
Roel De Coninck
3E
Quai à la Chaux 6 Kalkkaai,
1000 Brussels
roel.deconinck@3e.eu
http://www.3e.be/index.php

André De Herde
Université Catholique de Louvain
Place du Levant, 1
1348 Louvain-la-Neuve
deherde@arch.ucl.ac.be
http://www-climat.arch.ucl.ac.be

Ralf Klein
KaHo Sint-Lieven
Gebroeders Desmetstraat 1
9000 GENT
ralf.klein@bwk.kuleuven.be
http://www.kahosl.be/site/index.php?p=/en/page/11/welcome-to-kaho-sintlieven/

Erwin Mlecnik
Passiefhuis-Platform vzw
Gitschotellei 138
2600 Berchem
erwin.mlecnik@passiefhuisplatform.be
http://www.passiefhuisplatform.be/

Canada
Andreas Athienitis
Scientific Director
NSERC Solar Buildings Research Network Professor and Concordia
Research Chair Tier I
Dept. of Building, Civil and Environmental Engineering
Concordia University
1455 Maisonneuve W.
Montreal, Québec H3G 1M8
aathieni@encs.concordia.ca
http://www.solarbuildings.ca

Véronique Delisle
CanmetENERGY/Natural Resources Canada/Government of Canada
1615 Lionel-Boulet Blvd, P.O. Box 4800
Varennes, Québec J3X 1S6
veronique.delisle@rncan-nrcan.gc.ca
www.canmetenergy.nrcan.gc.ca

Michel Tardif
CanmetENERGY/Natural Resources Canada/Government of Canada
580 Booth Street
Ottawa, Ontario K1A 0E4
michel.tardif@rncan-nrcan.gc.ca
http://www.canmetenergy.nrcan.gc.ca

Denmark
Per Heiselberg, Anna Marszal
Aalborg University
Department 6 - Department of Civil Engineering
Sohngårdsholms Vej 57
9000 Aalborg
ph@civil.aau.dk
ajm@civil.aau.dk
http://en.aau.dk/
http://www.zeb.aau.dk

Søren Østergaard Jensen
Danish Technological Institute
Gregersen Vej
2630 Taastrup
soren.o.jensen@teknologisk.dk
http://www.teknologik.dk/

Kim B. Wittchen
Danish Building Research Institute
Aalborg University
Dr. Neergaards Vej 15
2970 Hørshom
KBW@SBi.dk
http://www.en.sbi.dk/

Finland

Riikka Holopainen, Jyri Nieminen, Sirje Vares
VTT Technical Research Centre of Finland
P.O. Box 1000
02044 VTT
jyri.nieminen@vtt.fi
http://www.vtt.fi/index.jsp

Ala Hasan and Mohamed H. Hamdy
Department of Energy Technology
School of Science and Technology
Aalto University
PO Box 14400
FI-00076 Aalto
ala.hasan@tkk.fi
Mohamed.Hassan@tkk.fi
http://hvac.tkk.fi/index_uk.html

France

François Garde
Campus universitaire Sud
Université de la Réunion
15 avenue René Cassin, BP 7151
97715 Saint Denis Messag, Cedex 9
garde@univ-reunion.fr
http://www.univ-reunion.fr/index.html

Germany

Karsten Voss
Bergische Universität Wuppertal
Haspeler Straße 27
42285 Wuppertal
kvoss@uni-wuppertal.de
http://www.btga.uni-wuppertal.de

Italy

Stefano Avesani, Roberto Lollini, Assunta Napolitano
EURAC Research
Insitute for Renewable Energy
Viale Druso n°1,
39100 Bozen/Bolzano
stefano.avesani@eurac.edu
roberto.lollini@eurac.edu
assunta.napolitano@eurac.edu
http://www.eurac.edu

Alessandra Scognamiglio
ENEA CR Portici
P.le E. Fermi - 80055 Portici (Napoli)
alessandra.scognamiglio@enea.it
http://www.portici.enea.it/index2.html

Valerio Calderaro
Università degli Studi di Roma "La Sapienza"
Piazzale Aldo Moro 5, 00185 Roma
valerio.calderaro@uniroma1.it
http://www.uniroma1.it/default_e.php

Salvatore Carlucci, Lorenzo Pagliano, Paolo Zangheri
Politecnico di Milano
Energy Department - eERG end-use Efficiency Research Group
Via Lambruschini 4, 20156 Milano
salvatore.carlucci@polimi.it
lorenzo.pagliano@polimi.it
http://www.energia.polimi.it/english/research/scheda_gruppo.php?id=14

Maurizio Cellura
Universitá degli di studi Palermo
Dipartimento di Ricerche Energetiche ed Ambientali (DREAM)
V.le delle Scienze - Ed. 9 - 90128 Palermo
mcellura@dream.unipa.it
http://portale.unipa.it/home/dipartimenti/dip_energetic

Korea

Gi Young Yang, Seungho Shin
Research Institute of Construction technology
Samsung C&T Corporation
1321-20, Seocho2-dong, Seocho-Gu, Seoul
pius.yang@samsung.com
seungho.shin@samsung.com
http://www.secc.co.kr/

Jun Tae Kim
Dept. Architectural Engineering
Kongju National University
275 Budae-dong, Cheonan, Chungnam Province
jtkim@kongju.ac.kr
http://www.kongju.ac.kr/index.jsp

New Zealand

Michael Donn
Victoria University of Wellington School of Architecture
PO Box 600, 139 Vivian St., Wellington
michael.donn@vuw.ac.nz
http://www.victoria.ac.nz/home/

Norway

Anna Grete Hestnes
The Research Centre on Zero Emission Buildings
Faculty of Architecture and Fine Art
Norwegian University of Science and Technology - NTNU
NO-7491 Trondheim
annegrete.hestnes@ntnu.no
http://www.sintef.no/projectweb/zeb

Tor Helge Dokka, Igor Sartori
NTNU/ SINTEF Building and Infrastructure
Forskningsveien 3 b
P.O.Box 124 Blindern
N-0314 Oslo
torhelge.h.dokka@sintef.no
igor.sartori@sintef.no
http://www.sintef.no/Home/Building-and-Infrastructure/

Harald N Røstvik
Sivilarkitekt Harald N. Røstvik AS
PB 806, 4004 Stavanger
hnr@telnett.no
http://www.sunlab.no/default.aspx

Portugal

Daniel Aelenei
Campus da Caparica
Department of Civil Engineering
Faculty of Science and Technology
Universidade Nova de Lisboa
2829-516 Caparica
aelenei@fct.unl.pt
http://www.fct.unl.pt/

Laura Aelenei
Unidade de Energia no Ambiente Construído - UEAC
Laboratório Nacional de Energia e Geologia - LNEG
Estrada do Paço do Lumiar, Edifício Solar XXI
1649-038 Lisboa
laura.aelenei@ineti.pt
http://www.ineti.pt

Helder Gonçalves
Laboratório Nacional de Energia e Geologia - LNEG
Estrada do Paço do Lumiar, Edifício Solar XXI
1649-038 Lisboa
helder.goncalves@LNEG.pt
http://www.lneg.pt

Spain

Jaume Salom, Eduard Cubi
Thermal Energy and Building Performance Group
IREC – Institut de Recerca en Energia de Catalunya
Josep Pla 2, B2, Ground floor
08019 Barcelona
jsalom@irec.cat
ecubi@irec.cat
http://www.irec.cat

Sweden

Joakim Widén
Energy Systems Programme
Department of Engineering Sciences, Solid State Physics
Uppsala University
P.O. Box 534
SE-751 21, Uppsala
joakim.widen@angstrom.uu.se
Personal website:
http://www.anst.uu.se/jowid957/

Björn Karlsson
Energy & Building Design
Lund University
Box 118

221 00, Lund
Bjorn.karlsson@ebd.lth.se
http://www.lu.se/lund-university

Switzerland
Armin Binz, Monika Hall
Fachhochschule Nordwestschweiz
Hochschule für Architektur, Bau und Geomatik
Institut Energie am Bau
St. Jakobs-Strasse 84
CH-4132 Muttenz
monika.hall@fhnw.ch
Armin.Binz@fhnw.ch
http://www.fhnw.ch/habg/iebau/

United States
Adam Hirsch, Shanti Pless, Paul Torcellini,
National Renewable Energy Laboratory
1617 Cole Blvd.
Golden, Colorado 80401-3305
adam.hirsch@nrel.gov
shanti.pless@nrel.gov
paul.torcellini@nrel.gov
http://www.nrel.gov/about/

Regular Participants

Attia, Shady
Université Catholique de Louvain, BELGIUM
shady.attia@uclouvain.be

Biesbroek, Katrien
Katholieke Hogeschool (KaHo) Sint-Lieven, BELGIUM
katrien.biesbroeck@kahosl.be

Bourrelle, Julien S.
Norwegian University of Science and Technology - NTNU, NORWAY
julien.bourrelle@ntnu.no

Bourdoukan, Paul
FRANCE
paul.bourdoukan@gmail.com

Calderaro, Isabella
Università degli Studi di Roma "La Sapienza" , ITALY
isabella.calderaro@alice.it

Candanedo, José A. and O'Brien, William
Concordia University, CANADA
j_candan@encs.concordia.ca
w_obrie@encs.concordia.ca

Castro, Natascha
National Institute of Standards and Technology, USA
natascha.castro@nist.gov

Chahwane, Layal
Université de Savoie, FRANCE
layal.chahwane@univ-savoie.fr

Davidsson, Henrik
Lund University, SWEDEN
henrik.davidsson@ebd.lth.se

Jones, Terrence E.
Energy Transformed Flagship, Low Emission Distributed Energy
The Commonwealth Scientific and Industrial Research Organisation (CISRO), AUSTRALIA
terry.jones@csiro.au

Lenoir, Aurélie
Université de la Réunion, FRANCE
aurelie.lenoir@univ-reunion.fr

Musall, Eike
Bergische Universität Wuppertal, GERMANY
emusall@uni-wuppertal.de

Nardi Cesarini, David and Spallacci, Maddalena
The Loccioni Group, ITALY
d.nardicesarini@loccioni.com
m.spallacci@loccioni.com

Noguchi, Masa
MEARU, Mackintosh School of Architecture, Glasgow, UK
m.noguchi@gsa.ac.uk

Prasad, Deo
Built Environment, University of New South Wales, AUSTRALIA
d.prasad@unsw.edu.au

Thyholt, Marit
NTNU/SINTEF Building and Infrastructure, NORWAY
marit.thyholt@sintef.no

Weiss, Tobias
Nussmüller Architekten ZT GmbH, AUSTRIA
tobias.weiss@nussmueller.at

Weiss, Werner
AEE INTEC, AUSTRIA
w.weiss@aee.at

Task 41

Solar Energy & Architecture

Maria Wall
Energy and Building Design, Lund University
Operating Agent for the Swedish Energy Agency, the Danish Energy Agency and Enova of Norway

TASK DESCRIPTION

The main goals of the Task are to help achieving high quality architecture for buildings integrating solar energy systems, as well as improving the qualifications of the architects, their communications and interactions with engineers, manufactures and clients. Increased user acceptance of solar designs and technologies will accelerate the market penetration. The overall benefit will be an increased use of solar energy in buildings, thus reducing the non-renewable energy demand and greenhouse gas emissions.

To achieve these goals, work is needed in three main topics:

A. Architectural quality criteria; guidelines for architects by technology and application for new products development.
B. Tool development for early stage evaluations and balancing of various solar technologies integration.
C. Integration concepts and examples, and derived guidelines for architects.

The first objective is to define general architectural quality criteria and extract recommendations for solar components and systems, to support manufacturers in developing existing products as well as new products. Specific criteria for the architectural integration of different solar energy components/systems will be developed in cooperation between architects, manufacturers and other actors. New adapted products should result from this activity as well as appropriate ways to use them.

The second objective concerns methods and tools to be used by architects at an early design stage, which need to be developed or improved. An example of such a tool can be how to visualize the solar energy concepts to show e.g. clients. Other examples can be tools needed to quantify and clearly illustrate the solar energy contribution and help balance the use of different active and passive solar technologies on the building envelope.

The last objective is to provide good examples of architectural integration, in the form of both existing projects that can be analysed as well as proposals for new projects. Buildings, installations and products will be included. Case studies will be an important basis to gain experience regarding the level of successful building integration, achieved solar energy contribution and to identify barriers related to e.g. technical and economical aspects and attitudes. New demonstration buildings will be developed in connection with the Task work and followed at least for the first part of the design stage, to learn from and to test guidelines and tools.

Communication tools and guidelines with facts and arguments for architects to help convince their clients to include solar energy systems will be produced. Arguments and facts related to architectural value, energy performance and life cycle costs are essential. Here, the arguments and facts need to be tailored for different building types and owner/user structures. The results will also serve as a basis for teaching material that could be used in e.g. architecture schools. To communicate the value of solar energy designs and technologies, the Task will carry out seminars, workshops and produce articles in architectural magazines, etc.

Scope

The scope of the Task includes residential and non-residential buildings. Both new and existing buildings will be included, for the climatic zones represented by the participating countries. Individual buildings as well as urban areas will be studied. In this way the potential impact of the Task can be large. Already cost-effective systems can, with a successful architectural integration, accelerate the market penetration. But also technologies not yet fully cost-effective can benefit from the work to pave the way to successful integration and user/client acceptance, and make the coming market penetration smoother. The work will build upon past IEA Tasks and other research projects related to building integration of solar systems and development of sustainable buildings.

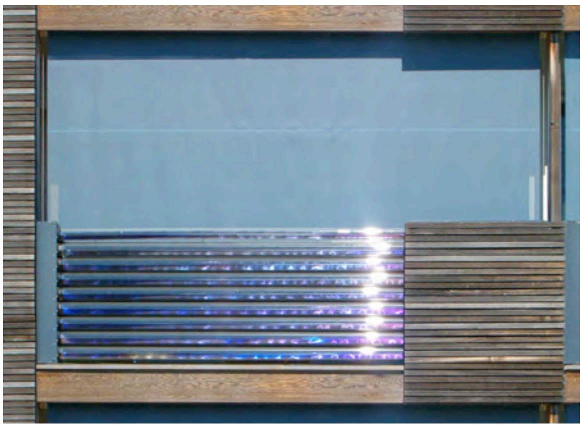
The Task is organized in three Subtasks, derived from the above described objectives and goals. The integration problems related to the different technologies (product development, method of integration) are treated in subtask A. The balance issues between the different types of solar gains, related to energy and cost impacts, are treated in subtask B. Finally the architectural integration issue is treated as a whole in subtask C, based on case studies.

The objectives will be achieved by the Participants in the following Subtasks and activities:

Subtask A: Criteria for Architectural Integration

This Subtask focuses on architectural integration of active solar energy collectors systems (solar thermal, PV and hybrids technologies) that offer an important potential for improvement regarding architectural integration. The objectives are to:

- Establish and communicate architectural criteria for the integration of active solar energy systems in the building envelope.
- Give recommendations to the industry to improve the architectural integration quality and flexibility of active solar products and systems (integrability).
- Bring together architects and product/system developers to understand each others needs.
- Educate/inform architects on integration characteristics for various technologies and on state of the art of innovative products.



Well integrated vacuum collectors as balcony rails. The residential building "Sunny Woods". Beat Kämpfen Architects, Switzerland.

Photo: EPFL-LESO, Switzerland

Results will consist of:

- Survey on architects needs for an increased/better use of active solar in buildings and to help identify related barriers.
- Document for architects that describes important architectural integration criteria for different categories of solar systems, with good examples.
- Document for product and system developers that describes important architectural integration design criteria for different categories of solar systems, with good examples.
- Initiate collaborations for the development of new products/systems e.g. through local seminars in connection with Task meetings.
- Dissemination of new knowledge to practicing architects and manufacturers through seminars.
- Task web-site page listing and describing available innovative products.
- Survey on active solar use potential based on: available exposed surfaces – structural compatibility – energy use compatibility – architectural sensitivity zoning. (If funding provided to Fraunhofer ISE).

Subtask B: Methods and Tools

This Subtask is focused on methods and tools for architects to use in the early design stage (EDS). The methods and tools should support EDS decisions and allow further development of the project at preliminary design and construction phases. The use of the building envelope to achieve a good balance of both active and passive solar utilisation is a central concern in this subtask and in the development of methods and tools. The work includes the collection of output material from existing tools used in demonstration projects to produce material for the Communication Guidelines (Subtask C).

The objectives are to:

- Achieve a comprehensive review of existing methods and tools (state-of-the-art) that architects currently use at EDS when designing buildings which integrate active/passive solar components.
- Identify current barriers that prevent architects from using the existing methods and tools for solar building design.
- Identify important needs and criteria for new or adapted methods and tools to support architectural design and integration of solar components at EDS.
- Provide clear guidelines for developers of methods and tools for architects designing solar buildings.
- Initiate communication with tool developers (industry) in order to stimulate the development of tools based on the guidelines written as a result of this Subtask.
- In collaboration with Subtask C, collect output data, figures, illustrations and facts produced by various tools in demonstration projects, to be included in the Communication Guidelines.

Results will consist of:

- State-of-the-art presenting existing methods and tools for architectural design and solar building design.
- Survey on architects' barriers, needs and criteria for new methods and tools to support architectural design and integration of active/passive solar components at EDS.
- Guidelines for the development of methods and tools for architects.
- Element libraries (method and examples) that could be used in design tools showing the visual impact of various solar options.
- Output material collected from existing tools used in demonstration projects to support the Communication Guidelines (with Subtask C).
- Local seminars for invited architects in connection to Task meetings. Regional/national seminars (with Subtask A, C).

Subtask C: Concepts, Case Studies and Guidelines

This Subtask is looking at concepts for architectural integration as well as case studies, with a whole building perspective. The Subtask also condenses the results into communication guidelines, with support from Subtasks A and B.

The objectives of this Subtask are:

- Develop concepts and principles for high quality architectural integration of solar systems, based on analyses of existing systems as well as proposals for future systems through national, and later on, international architectural colloquiums and workshops.
- Develop building concepts that utilize active and passive solar energy, achieving high quality architecture, sustainable solutions, attractive indoor climate and high energy performance. The developed concepts should aim at reducing the energy demand in buildings and increasing the fraction of renewable energy use such as solar energy.
- Develop knowledge and strategies to promote and implement high quality architecture using solar energy.

Results will consist of:

- Comprehensive collection and selection of case studies of high quality architecture and energy efficient building designs including solar solutions for new build and renovation for various building types (housing, offices, schools, etc.).
- Working method illustrated through selected examples of energy efficient or sustainable urban planning: Use tools to identify energy needs (Subtask B). Use other tools to identify attractive solar technologies to utilise the technical potential. Identify architectural design "rules" (orientation, slope, shading avoidance) to be followed to enable utilisation of the solar potential (Subtask A). These activities are to be combined when developing complete building designs.

- Presentation of working methods, designs, solar energy potentials through exemplary buildings in communication guidelines, in an IEA SHC web page, articles, architecture magazines, and at seminars for architects, engineers, component and system developers, clients, planners etc. The communication guidelines will include convincing arguments and facts with support from Subtask A and B.

One of the proposed case studies: CeRN Bursin, industry, Switzerland. Unglazed solar thermal collectors integrated in the façade. Left: details from the façade with nonactive elements and active solar collectors. Architect: Atelier Niv-o.

Photos: EPFL-LESO, Switzerland.

Duration

This Task was started on May 1, 2009 and remains in force until April 30, 2012.

ACTIVITIES DURING 2010

Two Task Expert meetings were held in 2010; the first in Bolzano, Italy, in March and the 2nd meeting in Graz, Austria, in September. The autumn meeting was linked to the EuroSun conference where experts also presented Task work.

The survey on barriers, needs and criteria was carried out within Subtask A and B. In total 14 countries participated in the survey: Australia, Austria, Belgium, Canada, Denmark, France, Germany, Italy, Norway, Portugal, Spain, South Korea, Sweden and Switzerland. The survey was closed in late autumn and the results and analyses are compiled into two reports, one from Subtask A and one from Subtask B. These reports will be finalized in early 2011.

A state-of-the-art of methods and tools for architects related to solar design was finalized (Subtask B). The report can be downloaded at the IEA SHC website.

Also, elements illustrating solar components have been developed (PV and solar thermal) to use in AutoCad and ArchiCad for illustrating various options of active solar integration into buildings. They are meant as examples, and hopefully in the future manufacturers will develop such elements for real products (including key data) that architects can then choose from in a library, to illustrate how their building will look with active components as building envelope cladding.

Guidelines for architects and for solar product and system developers respectively, are in progress (Subtask A). These guidelines are focused on the architectural integration criteria of solar products. The first chapters have been written. Good integration examples are collected.

Proposed case studies have been collected within Subtask C and will be continued during 2011. At the moment about 100 proposals are available. The process of selecting Task 41 case studies from the proposed ones are in progress. Selection criteria include architectural quality and energy performance.

Most of the experts now have funding for the Task work. Countries participating are; Australia, Austria, Belgium, Canada, Denmark, Germany, Italy, Norway, Portugal, Spain, Sweden and Switzerland. Also South Korea is participating, in waiting to become formal member of the IEA SHC programme. One expert from France participated during 2010 only; France will not join the Task. Recently, Singapore became member of the IEA SHC programme, and experts are now in planning to join Task 41 officially. This means that onwards, 14 countries are participating. See the list of the participants at the end. Updates of participation and results from the Task will be available on the website: http://iea-shc.org/task41.

ACTIVITIES PLANNED FOR 2011

Key activities planned for 2011 include:

- Finalize a report based on the survey on architects' barriers, needs and criteria related to architectural integration of solar systems (Subtask A).
- Finalize a report based on the survey on architects' barriers, needs and criteria related to methods and tools for solar design (Subtask B).
- Write guidelines for architects that describes important architectural integration criteria for different categories of solar systems, with good examples (Subtask A).
- Write guidelines for product and system developers that describes important architectural integration design criteria for different categories of solar systems, with good examples (Subtask A).
- Develop a list of available innovative products for integrated solar systems and put on a website (Subtask A).
- Test the developed elements for solar components, in computer programs (Subtask B).
- Write guidelines for the development of methods and tools for architects (Subtask B).
- Identify potential case studies of buildings and urban areas, work on and finalize the selection process

and organize seminars and workshops (Subtask C).

- Compile selected case studies into a document (Subtask C).
- Write the Communication Guidelines (Subtask C).
- Finalize national funding and approval of national participation letters.

TASK REPORTS PUBLISHED IN 2010

- State-of-the-Art of Digital Tools Used by Architects for Solar Design (2009).
  Editors: M-C. Dubois and M. Horvat. IEA SHC Task 41, Subtask B. Report T.41.B.1. This report presents a review of existing digital tools widely used today The review covers a total of 56 computer programs, classified according to three categories: 1) CAAD (computer-aided architectural design), 2) visualization, 3) simulation tools. The aim of this review is to analyse the current software landscape for building projects with a focus on early design phase (EDP). Download at:
  http://www.iea-shc.org/publications/task.aspx?Task=41.

OTHER PUBLICATIONS in 2010

- Zanetti, I., (2010). "Interactive tools and instruments supporting the design of building integrated PV". EuroSun 2010 International Conference on Solar Heating, Cooling and Buildings, September, 2010, Graz, Austria.
- Gagnon S, Dubois M-C & Horvat M (2010). High quality solar architecture: Do architects have tools supporting early design phase decisions? Eurosun 2010 International Conference on Solar Heating, Cooling and Buildings, September 2010 Graz, Austria.
- Farkas, K., Munari Probst, M. C., & Horvat, M. (2010). "Barriers and needs for building integration of solar thermal and photovoltaics". EuroSun 2010 International Conference on Solar Heating, Cooling and Buildings, September 2010, Graz, Austria.
- Giovanardi, A., Baggio, P. Lollini, R. Munari Probst, M. C. & Roecker, C. (2010). "Development of Solar Ventilated Façade System for Building Energy Retrofit". Eurosun 2010 International Conference on Solar Heating, Cooling and Buildings, September 2010, Graz, Austria.
- Munari Probst, M-C. & Roecker, C. (2010). "Architectural integration of solar thermal systems". EPFL, Switzerland. In Detail Green 01/10 pp. 42-45.
- On-line magazine at www.domusweb.it (ENEA and Domus), Italy. A series of articles within the topic "Forms of Energy". So far 7 articles (visited on 25/01/2011): Scognamiglio A. & Palumbo M. (2010): Article #1: http://www.domusweb.it/en/architecture/forms-of-energy-1/ Scognamiglio A. (2010): Article #2: http://www.domusweb.it/en/architecture/forms-of-energy-2/ Scognamiglio A. (2010): Article #3: http://www.domusweb.it/en/architecture/forms-of-energy-3/Palumbo M. (2010): Article #4: http://www.domusweb.it/en/architecture/forms-of-energy-4/ Scognamiglio A. & Palumbo M. (2010): Article #5:http://www.domusweb.it/en/architecture/forms-of-energy-5/ Palumbo M. & Scognamiglio A. (2010): Article #6:http://www.domusweb.it/en/architecture/forms-of-energy-6/ Scognamiglio A. (2010): Article #7: http://www.domusweb.it/en/architecture/forms-of-energy-7-/
- Geissler, Gosztonyi, Selke & Mach (2010). "OTTI Aktivhaus: Planung von Plus-Energie Gebäuden auf der Basis einer optimierten Nutzung der Gebäudeflächen für Energiebereitstellungstechnologien". Publisher: OTTI, Austria.
- Gagnon S. & Dubois M-C. (2010). Énergie solaire et architecture : une grande enquête sur les obstacles et défis pour les architectes. Conf. ACFAS, University of Montreal, Montreal, Quebec, Canada, May,

2010. Oral presentation with published abstract.

- Munari Probst, M. C., Schüler A. & Roecker C. (2010). "Bringing colours to solar collectors: a contribution to an increased building "integrability"". Conference: "Colour & Light in Architecture", Venice, 2010.
- Bouffard É, Gagnon S, Kanters J, Dubois M-C & Horvat M. (2011). Adequacy of current design tools and methods for solar architecture – results of IEA-SHC Task 41's international survey. PLEA Conference 2011, Louvain, Belgium. Accepted.

SEMINARS AND WORKSHOPS IN 2010

- "Certification and Quality of Building Integrated PV". March 2010, Bolzano, Italy. Organizer: EURAC.
- "Forms of Energy". June 2010, Rome, Italy. Organizers: EURAC and ENEA.
- "Solar Energy and Architecture – Case Studies of Buildings and Urban Areas". Linked to Klimaenergy fair, September 2010, Bolzano, Italy. Organizer: EURAC.
- "Opportunities of collaboration between the building and solar sectors. February 2010, Trübbach (Oerlikon), Switzerland. Organizer: ISAAC. www.bisolnet.ch.
- "Quality and reliability of building integrated PV modules and thermal collectors" August, 2010, Lugano, Switzerland. Organizer: ISAAC. www.bisolnet.ch.
- "Formal characteristics of photovoltaics", Workshop at DARK architects, March 2010, Trondheim, Norway. Organizer: NTNU.
- "Formal characteristics of photovoltaics", Workshop at ARC architects, September 2010, Trondheim, Norway. Organizer: NTNU.
- "Formal characteristics of photovoltaics", Workshop at Lund und Hagem architects, September 2010, Oslo, Norway. Organizer: NTNU.
- "Formal characteristics of photovoltaics", Workshop at Bergersens architects, September 2010, Trondheim, Norway. Organizer: NTNU.
- "Formal characteristics of photovoltaics", Workshop at LPO architects, October 2010, Oslo, Norway. Organizer: NTNU.

SEMINARS AND WORKSHOPS IN 2009

- "Facilitate the acceptance of solar installations in the built environment". March, 2009, Luzern, Switzerland. Organizer: ISAAC. www.bisolnet.ch.
- "Interactive tools and assistance for the architectural integration of solar installations". November, 2009, Lugano, Switzerland. Organizer: ISAAC. www.bisolnet.ch.

MEETINGS IN 2010

3rd Experts Meeting
March 17-18
Bolzano, Italy
(March 19: Workshop in Italian)

4th Experts Meeting
September 27-28
Graz, Austria
(in connection to EuroSun 2010)

MEETINGS PLANNED FOR 2011

5th Experts Meeting
March 29-31
Oslo, Norway
(April 1: Seminar in English/Norwegian)

6th Experts Meeting
September, last week
Preliminary in Australia
Workshop/seminar in connection

Extra meeting (a subgroup)
February 16
Copenhagen, Denmark
Objective: to identify development needs related to solar energy integration in urban planning; what could be included in Task 41 and what could be issues for a new Task.

TASK 41 NATIONAL CONTACTS

Operating Agent
Maria Wall
Energy and Building Design
Lund University
P.O. Box 118
SE-221 00 Lund, Sweden
maria.wall@ebd.lth.se

Subtask Leaders

Subtask A
Maria Cristina Munari Probst
Christian Roecker (co-leader)
EPFL-LESO
Bâtiment LE
Station 18
CH-1015 Lausanne, Switzerland
mariacristina.munariprobst@epfl.ch
christian.roecker@epfl.ch

Subtask B
Marie-Claude Dubois
School of Architecture, Laval University
1, Côte de la Fabrique, Québec,
Québec, G1R 3V6, Canada
Marie-Claude.Dubois@arc.ulaval.ca

Miljana Horvat (co-leader)
Department of Architectural Science
Ryerson University
350 Victoria St.,
Toronto, Ontario, M5B 2K3, Canada
mhorvat@ryerson.ca

Subtask C
Olaf Bruun Jørgensen
Esbensen Consulting Engineers
Gammel Køge Landevej 22
DK-2500 Valby, Denmark
obj@esbensen.dk

PARTICIPANTS

Australia
Mark Snow and Deo Prasad
Faculty of the Built Environment
University of New South Wales
Sydney 2052
m.snow@unsw.edu.au
d.prasad@unsw.edu.au

Austria
Susanne Geissler
Division Buildings & Heating
Austrian Energy Agency
Mariahilfer Straße 136
A-1150 Vienna
susanne.geissler@energyagency.at

Susanne Gosztonyi
Energy Department
AIT Austrian Institute of Technology
Giefinggasse 2
A-1210 Vienna
susanne.gosztonyi@ait.ac.at

Thomas Mach
Institute of Thermal Engineering
TU Graz / Graz University of Technology
Inffeldgasse 25/B
A-8010 Graz
thomas.mach@tugraz.at

Andreas Lechner and
Sophie Grünewald
Institute of Design and Typology
TU Graz / Graz University of Technology
Inffeldgasse 25/B
A-8010 Graz
andreas.lechner@tugraz.at
s.gruenewald@tugraz.at

Belgium
André de Herde and Catherine Massart
Architecture et Climat - UCL
Place du Levant, 1
B-1348 Louvain-La-Neuve
andre.deherde@uclouvain.be
catherine.massart@uclouvain.be

Canada
Marie-Claude Dubois, Pierre Côté, Shirley Gagnon and Émilie Bouffard
School of Architecture, Laval University
1, Côte de la Fabrique, Québec
Québec, G1R 3V6
pierre.cote@arc.ulaval.ca
shirley.gagnon.1@ulaval.ca
emilie.bouffard.1@ulaval.ca

Miljana Horvat, Michael Clesle,
Viktor Kuslikis and Alissa Laporte
Department of Architectural Science
Ryerson University
350 Victoria St.,
Toronto, Ontario, M5B 2K3, Canada
mhorvat@ryerson.ca
mclesle@ryerson.ca
vkusliki@ryerson.ca
alissa.laporte@ryerson.ca

Andreas Athienitis and Caroline Hachem
Dept. of Building, Civil and Environmental Engineering
Concordia University (Solar Buildings Research Network)
1455 Maisonneuve W., Montreal
Quebec, H3G1M8
aathieni@encs.concordia.ca
caroline_hachem@yahoo.com

Denmark
Olaf Bruun Jørgensen
Esbensen Consulting Engineers
Gammel Køge Landevej 22
DK-2500 Valby, Denmark
obj@esbensen.dk

Torben Esbensen
Esbensen Consulting Engineers
Møllegade 54-56
DK-6400 Sønderborg
torben@esbensen.dk

Karin Kappel
Solar City Copenhagen
Arkitekternes Hus
Strandgade 27A
DK-1401 København K
Denmark
kk@solarcity.dk

Alexandra Thygesen
AT Architects
Falkoner Allé 26 B
DK-2000 Frederiksberg
at@at-a.dk

France (no official participation)
Alain Filloux
Alphéeis
Espace Beethoven - Bâtiment N°2
1200 Route des Lucioles
F -06560 Valbonne
alain.filloux@alpheeis.com

Germany
Tilmann E. Kuhn and Francesco Frontini
Dept. Thermal Systems and Buildings
Fraunhofer Institut für Solare Energie-systeme ISE
Heidenhofstr. 2
D-79110 Freiburg
tilmann.kuhn@ise.fraunhofer.de
francesco.frontini@ise.fraunhofer.de

Gustav Hillmann and
Margarethe Korolkow
IBUS Architekten und Ingenieure GbR
Caspar-Theyß-Straße 14a
D-14193 Berlin
hillmann@ibus-berlin.de
margarethe.korolkow@ibus-berlin.de

Susanne Rexroth
HTW Berlin University of Applied Sciences Renewable Energies
Wilhelminenhofstr. 75A
D-12459 Berlin
susanne.rexroth@htw-berlin.de

Gisela Wicht
HTW Berlin University of Applied Sciences Renewable Energies
Ostendstrasse 1
D-12459 Berlin, Germany
gisela.wicht@htw-berlin.de

Italy
Roberto Lollini, Alessia Giovanardi
and Laura Maturi
EURAC research
Viale Druso/Drususallee 1
I-39100 Bolzano/Bozen
roberto.lollini@eurac.edu
alessia.giovanardi@eurac.edu
laura.maturi@eurac.edu

Alessandra Scognamiglio
Renewable Sources and Innovative
Solar Technologies Area
ENEA Portici Research Center
piazzale E. Fermi 1
I-80055 Portici (Na)
alessandra.scognamiglio@portici.enea.it

Norway
Klaudia Farkas and Anne Grete Hestnes
Department of Architectural Design, History, and Technology
Norwegian University of Science and
Technology - NTNU
NO-7491 Trondheim
klaudia.farkas@ntnu.no
annegrete.hestnes@ntnu.no

Merete Hoff, Marius Bjørge and
Vivianne Steinsåker
DARK Arkitekter AS
Drammensveien 130
N-0277 Oslo
mho@dark.no
marius.bjorge@dark.no
vis@dark.no

Rolf Hagen and Kate Hagen
Context AS
Rjukan Naeringspark, Bygg 270
N-3660 Rjukan, Norway
rolf@context.as
katie@context.as

Olaf Bruun Jørgensen
Esbensen Consulting Engineers
Gammel Køge Landevej 22
DK-2500 Valby, Denmark

obj@esbensen.dk

Axel Andreas Bjørnulf
Schüco International
PB 56, Bogerud
N-0621 Oslo, Norway
ABjoernulf@schueco.com

Portugal

Miguel Pires Amado and
Maria Rosário Ribeiro
FCT/UNL
Campus da Caparica
PT-2829-516 Caparica
ma@fct.unl.pt
rsa.ribeiro@fct.unl.pt

João Capucho de Freitas
GEOTPU/DEC/FCT
Campus da Caparica
PT-2829-516 Caparica
rdabreu@fct.unl.pt

Vasco Moreira Rato
ISCTE-IUL Instituto Universitário de Lisboa
Av^a Forças Armadas, Lisboa
vasco.rato@iscte.pt

Carlos Barbosa, Ana Mestre, Eduardo Gonçalves, Marco Silva, Paulo Bago d'Uva, João Rebolo and João Santa Rita
IADE-Instituto de Artes Visuais, Design e Marketing
Av. D. Carlos 1, 4
PT-1200-649 Lisboa
carlos.barbosa@iade.pt
ana.mestre@susdesign.org
muaddib.mail@gmail.com (E. Gonçalves)
marco.silva@iade.pt
paulo.b.uva@gmail.com
jtrebolo@msn.com
joaosr65@gmail.com

Singapore

Stephen K Wittkopf
Solar Energy Research Institute of Singapore (SERIS)
National University of Singapore (NUS)
7 Engineering Drive 1
Building E3A #06-01
Singapore 117574
stephen.wittkopf@nus.edu.sg

South Korea

Jun Tae Kim
Department of Architectural Engineering, Kongju National University
275 Budae-Dong, Cheonan
Chungnam 330-717
jtkim@kongju.ac.kr

Spain

María José Jiménez and Ricardo Enriquez Miranda
Energy Efficiency in Building Unit
CIEMAT
Av. Complutense, 22.
E-28040 Madrid, España
mjose.jimenez@psa.es
ricardo.enriquez@ciemat.es

Sweden

Marja Lundgren, Erik Eriksson, Ulrika Stenkula and Karina Antin
White Arkitekter
P.O. Box 4700
Östgötagatan 100
SE-116 92 Stockholm
marja.lundgren@white.se
erik.eriksson@white.se
ulrika.stenkula@white.se
karina.antin@white.se

Maria Wall and Jouri Kanters
Energy and Building Design
Lund University
P.O. Box 118
SE-221 00 Lund, Sweden
maria.wall@ebd.lth.se
jouri.kanters@ebd.lth.se

Switzerland

Doris Ehrbar and Marcel Hohl
Lucerne University of Applied Sciences and Arts
Dept. of Engineering and Architecture
Competence Center for Typology and Planning
Technikumstrasse 21
CH-6048 Horw
doris.ehrbar@hslu.ch

marcel.hohl@hslu.ch

Kim Nagel and Isa Zanetti
SUPSI-DACD-ISAAC
Swiss BiPV centre of competence
Via Trevano
CP 105
CH - 6952 Canobbio
kim.nagel@supsi.ch
isa.zanetti@supsi.ch

Maria Cristina Munari Probst
Christian Roecker
EPFL-LESO
Bâtiment LE
Station 18
CH-1015 Lausanne, Switzerland
mariacristina.munariprobst@epfl.ch
christian.roecker@epfl.ch

Andreas Witzig
Vela Solaris AG
Stadthausstrase 125
CH-8400 Winterthur
Switzerland
andreas.witzig@velasolaris.com

Task 42

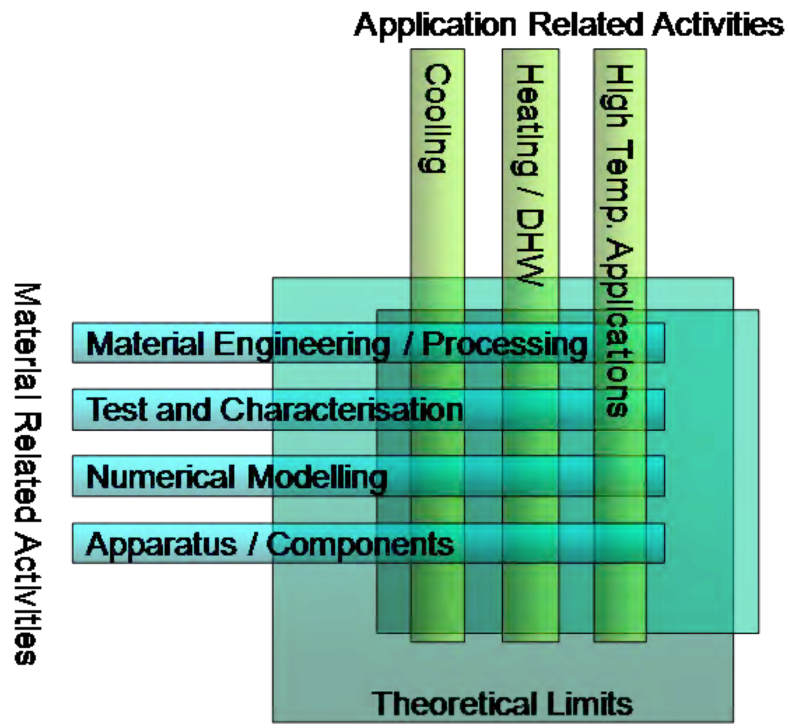
Compact Thermal Energy Storage: Material Development for System Integration

Wim van Helden
Energy Research Centre of the Netherlands (ECN)
Operating Agent for NL Agency

Andreas Hauer
Centre for Applied Energy Research (ZAE, Germany)
Operating Agent for the Danish Energy Agency

TASK DESCRIPTION

The objective of this Task is to develop advanced materials for compact storage systems, suitable not only for solar thermal systems, but also for other renewable heating and cooling applications such as solar cooling, micro-cogeneration, biomass, or heat pumps. The Task covers phase change materials, thermochemical and sorption materials, and composite materials and nanostructures, and includes activities such as material development, analysis, and engineering, numerical modeling of materials and systems, development of storage components and systems, and development of standards and test methods. The main added value of this Task is to combine the knowledge of experts from materials science as well as solar/renewable heating and energy conservation.



This Task deals with advanced materials for latent and chemical thermal energy storage, on three different scales:

- material scale, focused on the behavior of materials from the molecular to the 'few particles' scale, including e.g. material synthesis, micro-scale mass transport, and sorption reactions;
- bulk scale, focused on bulk behavior of materials and the performance of the storage in itself, including e.g. heat, mass, and vapor transport, wall-wall and wall-material interactions, and reactor design; and
- system scale, focused on the performance of a storage within a heating or cooling system, including e.g. economical feasibility studies, case studies, and system tests.

The work in the Task is structured in materials oriented, application oriented and cross-cutting working groups.

Subtask A – Materials

Working Group A1: Material Engineering and Processing

The activities in this Working Group focus on engineering new materials or composites, i.e. changing the properties of existing materials and developing new materials with better performance, lower cost, and improved stability. Eventually, this should lead to the ability to design new materials tailor-made to specification. The materials under consideration are those relevant to thermal energy storage using sensible mode, phase change, as well as chemical reactions and sorption technologies.
With respect to materials processing, the work focuses on the processing of raw materials that is required to make

these materials function in a realistic environment. In nearly all cases, storage material cannot be used to store heat in its raw form, but e.g. needs to be processed into a slurry, encapsulated, or otherwise processed.

This Working Group includes the following activities:

- synthesis of new materials;
- determining material characteristics such as phase diagrams;
- determining the relation between material performance and material structure and composition, in order to direct the search for improved materials;
- creating material safety data sheets;
- determining the role and importance of material containers.
- finding optimal methods for micro- and macro encapsulation of storage materials (particularly phase change, sorption, and thermochemical materials);
- processing phase-change slurries; and
- finding new combinations of materials.

Working Group A2: Tests and Characterisation

The performance characteristics of novel thermal energy storage materials, like phase-change materials or thermochemical materials, often cannot be determined as straightforward as with sensible heat storage materials. In order to have proper comparison possibilities appropriate testing and characterisation procedures should be developed and assessed.

The activities of this Working Group are aimed at developing these new procedures and include:

- comparative testing of materials and their required methods;
- long-term stability determination; and
- (pre-)standardisation of testing methods.

Working Group A3: Numerical Modelling

The activities in this working group are aimed at developing and testing numerical models that help to understand and optimise the material behaviour and the dynamic behaviour of compact thermal energy storage systems and components. Ultimately, these numerical models could help to find ways to optimise the materials in combination with the system components. The activities in this working group help to lay the foundation for such models.

The Working Group includes the following activities:

- Micro-scale modelling
- Meso-scale modelling
- Macro-scale modelling
- Multi-scale approach
- Thermo-mechanical modelling
- Reactor models

Working Group A4: Apparatus/ Components

The storage apparatus is composed of the storage material and the equipment necessary to charge and discharge the storage material in a controlled and optimal way. This includes heat and mass transfer equipment like heat exchangers and pumps or fans and (chemical) reactors. Methods for the design and optimisation of components and apparatus should be developed, together with appropriate testing methods and procedures to assess the long-term behaviour of an apparatus:

- storage container and reactor design;
- storage apparatus design, based on the selected storage materials;
- improve heat transfer from material to reactor wall or heat exchanger wall;

- apparatus performance assessment;
- assessment of durability of components; and
- develop and apply test and validation methods for storages.

Subtask B – Applications

There are several applications for compact thermal energy storage technologies, each with a different set of boundary conditions for the technology. Although the applications themselves place very different requirements on storage technology, the steps that must be taken are very similar for all applications. Hence, the activities within the Working Groups in this Subtask are very similar as well.

The activities in these Working Groups serve the underlying guidance principle of the materials development within the limitations of the application. The materials development will be directed by the desired system performance. A constant assessment of performance criteria for a given application will be used to determine the chances for a given material/system combination. These criteria can come from economic, environmental, production technology or market considerations.

Activities in the Application Working Groups include:

- inventory and analysis of existing store types, their theoretical and practical energy and power density, their possible application and their costs (if available) following the results of IEA SHC Task 32 and IEA-ECES Tasks;
- definition of application boundary conditions, such as load, demand, environment, dimensions, etc.;
- definition of required thermo-physical properties for each application;
- selection of relevant candidate materials and system technologies;
- storage system design, based on the selected storage materials (link to A2) and applications;
- assessment of durability of components
- system performance assessment and validation;
- numerical modelling on the application level;
- case studies;
- economical modelling;
- feasibility studies;
- market potential evaluations.

This subtask is subdivided in three Working Groups, each representing a particular application or group of similar applications:

- Working Group B1: Cooling
- Working Group B2: Heating / DHW
- Working Group B3: High Temperature Applications

Subtask C – Cross-Cutting

Working Group C: Theoretical Limits

The objective of this Working Group is to determine the theoretical limits of compact thermal storage materials and systems from a physical, technical and economical viewpoint. In short, this Working Group defines the maximum possible performance that can be expected from a thermal storage system in a given application. As such, it gives a reference point with which the performance of lab tests, field tests, and real-life systems can be compared. In a first step physical limits shall be determined, e.g. the energy stored per volume and per mass as a function of temperature, with respect to different mechanisms as sensible, latent, sorption or chemical storage. In a second step technical aspects shall be evaluated. In many cases the energy storage density and the efficiency of the system are deteriorated when a large specific thermal power must be drawn from the system. In a third step economical constraints of storage systems shall be evaluated.

Duration

This is a fully Joint Task with the IEA Energy Conservation through Energy Storage Programme. The Task started on January 1, 2009 and remains in force until December 31, 2012.

ACTIVITIES DURING 2010

The Task activities in the subsequent working groups were as follows:

Materials engineering and processing: the decision was made to start with a materials database, and incorporate safety data. The materials data will be supplied by all experts. A short report on the micro-encapsulation of inorganic PCM's was finished in concept. Samples of newly synthesised zeolites and composites were made and sent to other institutes for characterisation.

Materials testing and characterisation: The first comparison was made of the round-robin test of different PCM samples. There are considerable differences in the measured values. The round-robin will be completed and the results used to make a proposal for a normalised testing procedure.

Numerical modelling: A first draft of the report describing numerical modelling techniques was finished.

Apparatus and components: a mind map was produced describing all the aspects of the design process for a thermal storage. The design process was divided into consecutive steps.
Cooling applications: a schematic overview of available cold storage applications examples was made, in the temperature range from -40 °C to 40 °C.

Heating and domestic hot water applications: an overview was made of the Task experts that are doing performance simulations for either technical performance, economical performance or that can provide experience from prototype testing.
Theoretical limits: a study into the physical limits of thermal storage was drafted. An inventory was made of the different ways to categorise a storage system.

ACTIVITIES PLANNED FOR 2011

Key activities planned for 2011 include:

- Set up of storage materials data base.
- Results of round-robin and comparison of characterization of compact storage materials.
- Report on the state-of-the-art modeling techniques of PCM/TCM materials.
- Report on storage design aspects and design flow charts.
- Description and performance analysis of selected cooling applications
- Setting up a list of boundary conditions and requirements for the room heating and domestic hot water application area
- Report on state of the art of high temperature storage applications

REPORTS PUBLISHED IN 2010

No reports were published.

MEETINGS IN 2010

3rd Experts Meeting
April 21-23
Bordeaux, France

4th Experts Meeting
September 21-23
Graz, Austria

MEETINGS PLANNED FOR 2011

5th Experts Meeting
February 20-21
Belfast, Northern Ireland
(in conjunction with IC-SES Conference)

6th Experts Meeting
September 20-22
Minneapolis, MN, USA

TASK 42/ANNEX 24 CONTACTS

Operating Agents
Andreas Hauer
ZAE Bayern
Germany
hauer@muc.zae-bayern.de

Wim van Helden
Energy research Centre of the Netherlands ECN
The Netherlands
wim@wimvanhelden.com

Working Group A1 Leader
Elena Palomo
University of Bordeaux
France
elena.palomo@bordeaux.ensam.fr

Working Group A2 Leader
Stefan Gschwander
Fraunhofer Institute for Solar Energy Systems FhG-ISE, Freiburg
Germany
Stefan.Gschwander@ise.fraunhofer.de

Working Group A3 Leader
Camilo Rindt
Eindhoven University of Technology
The Netherlands
C.C.M.Rindt@wtb.tue.nl

Working Group A4 Leader
Wim van Helden

Working Group B1 Leader
Motoi Yamaha
Chubu University, Tokyo, Japan
yamaha@isc.chubu.ac.jp

Working Group B2 Leader
Jane Davidson
University of Minnesota, Minneapolis
USA
jhd@me.umn.edu

Working Group B3 Leader
Lluisa Cabeza
University of Lleida
Spain
lcabeza@diei.udl.cat

Working Group C Leader
Eva Günther
ZAE Bayern, Garching
Germany
guenther@muc.zae-bayern.de

Australia
Frank Bruno
University of South Australia
Frank.Bruno@unisa.edu.au

Austria
Dagmar Jähnig
AEE Intec
d.jaehnig@aee.at

Olivier Pol
Arsenal
Olivier.Pol@arsenal.ac.at

Wolfgang Streicher
TU Graz
w.streicher@tugraz.at

Bernhard Zettl
ASiC Austria Solar Innovation Center
zettl.bernhard@asic.at

Belgium
Johan Van Bael
VITO
johan.vanbael@vito.be

Canada
Handan Tezel
University of Ottawa
handan.tezel@uottawa.ca

Denmark
Simon Furbo
Technical University of Denmark
sf@byg.dtu.dk

France
Elena Palomo
Universite Bordeaux
palomo_elena@yahoo.fr

Frédéric Kuznik
Thermal Science Centre of Lyon
frederic.kuznik@insa-lyon.fr

Lingai Luo
University of the Savoie
Lingai.Luo@univ-savoie.fr

Philippe Papillon
INES
philippe.papillon@cea.fr

Philippe Stevens
EDF
philippe.stevens@edf.fr

Germany
Andreas Hauer
ZAE Bayern
hauer@muc.zae-bayern.de

Franziska Scheffler
University of Magdeburg
Franziska.Scheffler@ovgu.de

Henner Kerskes
ITW Stuttgart
kerskes@itw.uni-stuttgart.de

Jimmy Ofili
Lehrstuhl für Chemische Reaktionstechnik
Jimmy.Ofili@crt.cbi.uni-erlangen.de

Frank Salg
Vaillant GmbH
frank.salg@vaillant.de

Oliver Opel
Leuphana Universität Lüneburg
opel@leuphana.de

Peter Schossig
Fraunhofer ISE
peter.schossig@ise.fraunhofer.de

Roland Heinzen
University of Kassel
heinzen@uni-kassel.de

Italy
Valerio Lo Brano
University of Palermo
lobrano@dream.unipa.it

Netherlands
Camilo Rindt
Technical University Eindhoven
c.c.m.rindt@tue.nl

Marco Bakker
Energy research Center of the Netherlands ECN
m.bakker@ecn.nl

Slovenia
Venceslav Kaucic
National Institute of Chemistry
slavko.kaucic@KI.si

Spain
Ana Lazaro
Universidad de Zaragoza
ana.lazaro@unizar.es

Cristina Prieto
Abengoa Solar NT
cristina.prieto@solar.abengoa.com

Lluisa Cabeza
University of Lleida
lcabeza@diei.udl.es

Miren Blanco
Tekniker
mblanco@tekniker.es

Patricio Aguirre
Tecnalia
patricio.aguirre@tecnalia.com

Rocio Bayon Cabeza
CIEMAT

rocio.bayon@ciemat.es

Sweden
Viktoria Martin
KTH
vmartin@kth.se

Switzerland
Elimar Frank
SPF
elimar.frank@solarenergy.ch

Robert Weber
EMPA
robert.weber@empa.ch

Turkey
Halime Paksoy
Cukurova University
hopaksoy@cu.edu.tr

United Kingdom
Philip Griffiths
University of Ulster, Belfast
p.griffiths@ulster.ac.uk

Changying Zhao
University of Warwick
C.Y.Zhao@warwick.ac.uk

Phil C. Eames
CREST; University of Loughborough
p.c.eames@lboro.ac.uk

United States
Jane Davidson
University of Minnesota
jhd@me.umn.edu

Task 43

Advanced Solar Thermal Testing and Characterization for Certification of Collectors and Systems

Les Nelson
Western Renewables Group
Co-Operating Agent for the U.S. Department of Energy

Jan Erik Nielsen
PlanEnergi
Co-Operating Agent for the Danish Energy Agency

Kevin DeGroat
Antares Group, USA
Program Manager

TASK DESCRIPTION

Task 43 is an international collaboration focusing on research and development, where needed, of new test and certification procedures for conventional and advanced solar thermal products, at both the collector and system levels. The scope of the task includes performance testing and characterization, qualification testing, environmental impact assessment, accelerated aging tests, numerical and analytical modelling, component substitution procedures, and entire system design assessment. Task activities draw on the knowledge of industry, testing laboratories, standard-setting authorities and certification bodies in the areas of solar collector and system performance and durability to ensure wide-ranging involvement of affected stakeholders. By researching testing issues and investigating innovative approaches, the outputs of this task will help optimize the time and resources industry, laboratories and certification bodies expend on testing and certification. Consumer protection and the development and dissemination of credible information on solar heating and cooling benefits are guiding principles of this Task.

Stakeholders in Task 43 activities will work out the methods to be used to apply the Task research results to specific products, standards and certifications. Task results will be communicated to those legal authorities who define how certification shall be conducted, for use as they see fit.

Task 43 is organized into two Subtasks:

- **Subtask A**: **Collectors**
  (Lead country: Spain)

  The objective of Subtask A is to examine existing testing and certification procedures for all types of solar thermal collectors, with the objective of identifying opportunities for improvement and harmonization.

- **Subtask B**: **Systems**
  (Lead Country: Germany)

  The objective of Subtask B is to perform analyses of testing and certification procedures for entire solar thermal systems.

MAIN DELIVERABLES

The results of the Task will be several technical reports and, potentially, changes to test standards and certification protocols based on the results of the Task work. Major outcomes will include:

- Roadmaps for Both Task A and Task B activities going forward.
- State-of-the-art white paper on collector testing, measurement and certification issues.
- Report on the results of round-robin collector test projects now underway in Europe and North America.
- If deemed appropriate, draft recommendations for revising collector performance test standards, qualification criteria, and/or safety test standards .
- Report regarding computer modeling versus empirical testing of systems and balance of system components.
- Report regarding the impact of component substitution and down/upsizing of systems on system performance.
- Reports/white papers regarding the establishment of a collector “class” system for Impact Resistance Testing, Exposure Testing, and Mechanical Load Testing.
- Joint meetings with testing and certification stakeholders to promote international harmonization.
- Determination of the advisability of pursuing a global certification scheme.
- A communication plan for distributing information on the outcomes of Task activities to stakeholders.

Duration

The Task started on July 1, 2009 and will remain in force until June 30, 2012.

RESULTS IN 2010

Subtask A: Collectors

Low to medium temperature collector work has been advancing under the EN revision process. Some of the major developments include:

- Results of mechanical load tests are now categorized in classes, with documentation developed. Positive and negative loads will be required on all compact systems and collectors. Structural safety requirements for CE Marking Standards must be met.

- Liaison with roofing group TC128 and 254 is being pursued to harmonize work and recommendations.

- For impact resistance tests, the annexes to the standard will be changed from informative to mandatory, and group consideration of elimination of the steel ball impact test in favour of ice ball testing-only continues. A workshop with ESTIF has been proposed to develop ways to simplify and improve ice ball testing if it is decided that tests using ice balls only will become mandatory. NREL began conducting extensive impact tests that will provide results for developing improved test procedures. A diagram of NREL's test apparatus is shown here.

- Rain penetration testing will now eliminate the several alternative measurements involving weighing and humidity sensors, powders, etc., by substituting a visual inspection with guidance on inspection metrics and timing. Final language will be developed in a future teleconference.

- Annex B on exposure testing is fully developed and will become part of the WG1 minutes. There are still some questions on sequence and duration that may be answered by 1-year exposure tests that are currently in process – for now duration will remain at 30 days. An important change is specification of a total dose for radiation rather than a per day dose. For Class A the minimum total dose would be 500 MJ/m2, rising to 650 MJ/m2 for Class B and 720 MJ/m2 for Class C.

- Franz Helminger of AIT has developed a proposed methodology for stagnation temperature testing of collectors. Task participants are in agreement that stagnation testing should be conducted, and recommend that stagnation information appear in product manuals only, and not on collector labels.

- Wind effects on unglazed collectors is significant, but there is not a good correlation between artificial wind and natural wind in estimating performance, yet natural wind conditions are impossible to replicate. Because of difficulties in obtaining replicable results from either method only, testing under a combination of artificial and natural conditions will continue as the preferred method.

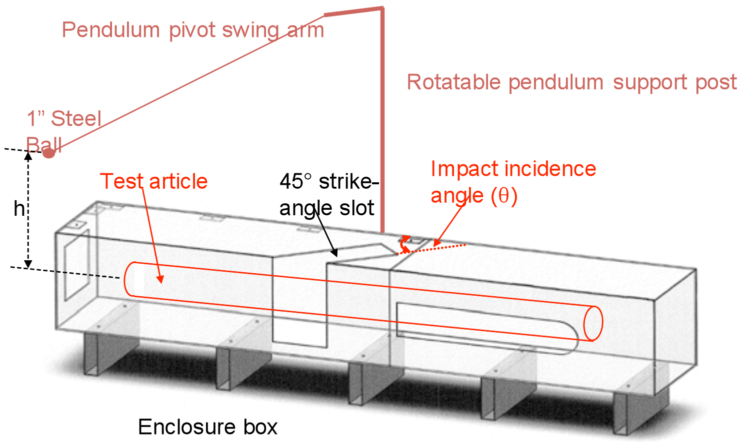


Figure 1. NREL steel ball and hail test apparatus.

Air Heating Collector developments include:

- Canadian Standards Association has promulgated a draft standard, with the public comment period ending in early 2011. The standard is expected to be final by October 2011. ISE Fraunhofer will work with the CSA standard and

Alfred Brunger to develop recommendations for harmonizing with the ongoing EN revision process.

Concentrating Collector developments include:

- SRCC Standard 600 has been promulgated and is being used as a starting point for revisions to EN by TC312/WG1. There are likely to be some differences in approach and improvements that will be recommended back to SRCC.
- In the U.S., two laboratories are currently testing products in accordance with Standard 600. SRCC and NREL are beginning to develop detailed guidance on specific operational testing issues as they are encountered.
- Concentrating collector definitions are being developed by CENER in coordination with AENOR (CSP) work. The Task 43 participants have begun to fill in/refine missing definitions at the meeting. The work will be completed using the Wiki tool.
- Draft language for EN12975 related to performance of tracking, concentrating collectors has been developed and should be approved no later than early spring 2011.
- ISE Fraunhofer has been developing alternatives to QDT and will have a paper ready for discussion and consideration for incorporation into proposed EN revisions.

Subtask B: Systems

- Roadmap of testing and certification issues for systems developed in 2009, further refined in 2010, including approaches to improve existing systems and harmonize standards and certification.
- Report on norms for systems testing and characterization that addresses system boundaries and definitions.
- Round robin testing of collectors and systems began under the QAiST program in Europe. Test results will be used to compare results among laboratories and identify differences in procedures or outcome that could be standardized. North American test labs Exova and FSEC committed to participating.

Results from the Energy Output Calculator
#NAME?

Identification label for the solar collector: Not specified

Date of evaluation: 8 October, 2010

Monthly irradiance and yield per collector unit (kWh)

	Irradiance	Yield (three collector mean temperatures)		
		25°C	50°C	75°C
January	51	14	3	0
February	128	47	23	7
March	255	114	66	29
April	337	169	104	57
May	427	234	152	83
June	425	245	160	90
July	410	247	157	86
August	356	214	132	70
September	257	139	80	39
October	151	68	38	17
November	63	23	8	1
December	33	7	0	0
Year	**2,893**	**1,520**	**923**	**480**
Uncertainty		*±15*	*±25*	*±25*

Location: Stockholm
Longitude: -18.08
Latitude: 59.35
Climate data, time period: 1996-2005

Collector information (all inputs are based on aperture)
Aperture area: 2.5 m²
Evaluation method: Steady state
η_0 0.700
$F'(\tau\alpha)_{en}$ 0.710
$K_{\theta,d}$ 0.908
a_1 3.6 W/m² K
a_2 0.015 W/m² K²
Tilt angle: 45°
IAM Type: Simple, one-direction
$b_0 = 0.1$

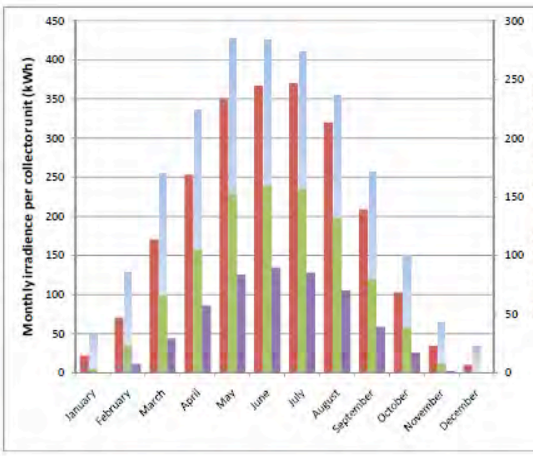


Figure 2. Prototype Performance Simualtion.

- A performance simulation tool that can produce meaningful results with a minimal set of data inputs is under development, and a prototype of the tool has been demonstrated. A screenshot from the tool is shown in Figure 2.

- Approaches for evaluation and testing of solar combi-systems were developed and discussed with industry and experts in combi-systems at the Stuttgart technical meeting. Specific work presented included:
    - Results of France's work on test ing of combi-systems
    - Testing of domestic hot water systems by means of up and down scaling;
    - Test results of solar thermal systems combined with heat pumps, different system configurations, and how they impact testing – initial contact with participants in Task 44 was made to coordinate work.

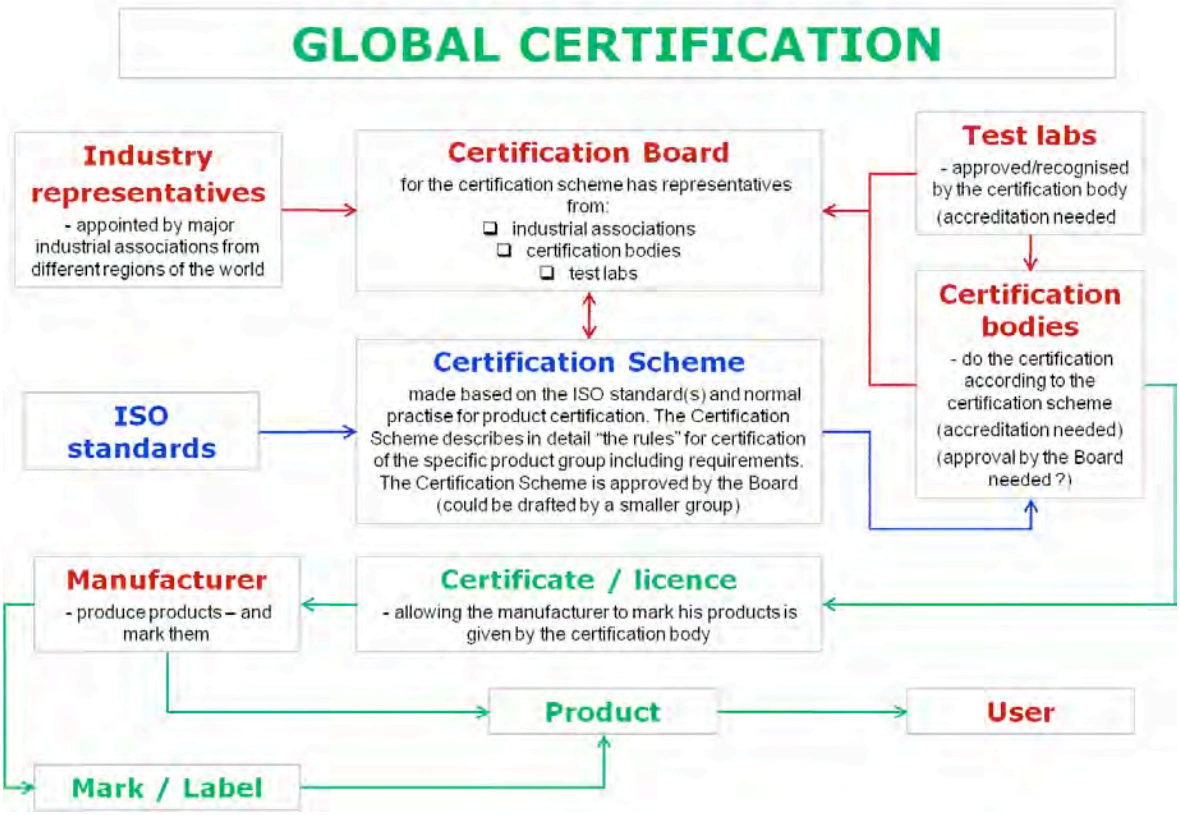


Figure 3. Global Certification Approach.

Other results

- An important outcome of the Task 43 work is the re-initiation of the ISO 180 working group for collectors. Agreement has been obtained to open the ISO collector standards for revision - and revise the ISO standards in parallel with the revision of the EN collector standards. The objective is to arrive at common EN/ISO standards for solar collectors.
- If one global standard for collectors can be established, it could also be possible to make a global certification scheme for solar collectors. Discussion on this issue is ongoing in the task group. The figure below represents the concept for engaging certification bodies in the harmonization effort.

- Several task participants presented papers at the EuroSun 2010 conference on work they are conducting under the task, including Kevin DeGroat on Task 43, Jan-Erik Nielsen on Solar Keymark, representatives from CENER, ITW, AIT and other laboratories active in Task 43.

WORK PLANNED FOR 2011

- **Concentrators**
  - NREL's approach to IAM measurement will be posted on the Task Wiki site and comments/interest in collaboration solicited from Task participants
  - Further efforts to integrate SRCC Standard 600 test methodology with EN concentrator test standard development activities will continue
- **Durability Testing**
  - NREL will make ice ball/steel ball correlation work available for use in finalizing impact test requirements
  - The agreement on how the CE Mark concerning safety and structural issues will be posted as final.
- **Power Failure Testing**
  - Stefan Albrecht's material will be posted on the Wiki site and Kevin DeGroat will start drafting recommendations for incorporating it into testing.
- **Round Robin Collector Testing**
  - Independent Round Robin Test programs will continue, and will approach or achieve completion in 2011.
- **Air Collectors and Systems**
  - Release of the final CSA air collector testing standard is expected in late 2011.
  - Test methods for air collector-based systems will be investigated.
- **Global Certification**
  - Draft certification scheme will be finalized and made available.
  - ISO TC180 interaction to discuss interest/concerns.
- **Heat Pumps and Solar Thermal**
  - Methods for certification of combined solar thermal/heat pump systems will continue to be explored.
- **In-Situ Monitoring of Systems**
  - Work in this area can draw on the experience of the California Solar Initiative Thermal Program, which has established a requirement for in-situ monitoring of larger systems with a 70/30 annual performance true up incentive structure. This monitoring scheme commenced in October 2010, and several projects have been completed as of start of 2011.
- **Component/Material Substitution Qualification and Safety Testing**
  - Work to establish methods for substituting system components and materials will continue. At issue is determining the effect on system performance (and resulting incentive structures or energy production labeling) when substitution is allowed.
- **Communications**
  - Work to populate the Task website with up to date work products will continue.
- **Recruitment**
  - Efforts to involve additional countries in Task 43 activities will be aggressively pursued.

REPORTS PUBLISHED IN 2010

No publically available reports were published in 2010.

REPORTS PLANNED FOR 2011

The following reports will be available on the SHC website:

- Roadmap for Subtask A, Collectors
- Roadmap for Subtask B, Systems

MEETINGS IN 2010

2nd Task Experts Meeting
February 9 - 10
Stuttgart, Germany

3rd Task Experts Meeting
October 5 – 6
Graz, Austria

MEETINGS PLANNED FOR 2011

4th Task Experts Meeting is planned to be held in conjunction with the American Solar Energy Society (ASES) "Solar 2011" Conference in Raleigh, North Carolina, USA, most likely on the 17th of May. A
one-day Industry Workshop is being organized for the day preceding the Conference, May 18th.

The 5th Task Experts Meeting location and date has not been finalized, however European venues in September, October and November 2011 are under consideration.

TASK 43 NATIONAL CONTACTS

Co-Operating Agent
Les Nelson
Western Renewables Group
30012 Aventura, Ste. A
Rancho Santa Margarita, CA 92688
USA
lnelson@westernrenewables.com
Phone: (949) 713-3500

Co-Operating Agent
Jan Erik Nielsen
PlanEnergi
Jyllandsgade 1
9520 Skørping
DENMARK
jen@solarkey.dk
Phone: +45 96820400

Program Manager
Kevin DeGroat
Antares Group
4351 Garden City Drive, Ste. 301
Landover, MD 20785
USA
kdegroat@antares.org
Phone: (301) 731-1900 Ext. 14

Leader Subtask A (Collectors)
Enric Mateu Serrats
CENER (National Renewable Energy Center)
Ciudad de la Innovación, nº 7
31621 Sarriguren (Navarra)
SPAIN
emateu@cener.com
Phone: +34 948 25 28 00

Leader Subtask B (Systems)
Harald Drück
University of Stuttgart (ITW)
Pfaffenwaldring 6
70550 Stuttgart
GERMANY
Phone: +49-(0)711-685-635 53

Task 43 Participants

Alfred Brunger	alfred.brunger@exova.com	Exova (formerly Bodycote)
Ana Neves	ana.neves@ineti.pt	INETI
Andreas Bohren	andreas.bohren@solarenergy.ch	University of Applied Sciences Rapper-swil HSR
Andreas Haberle	andreas.haberle@pse.de	PSE AG
Barry Johnston	barry@solartwin.com	Solar Twin
Bengt Perers	bpr@du.se	Delarna University
Daniel Eggert	eggert@isfh.de	Institut für Solarenergieforschung Hameln (ISFH)
Doug McLenahan	dmcclena@nrcan.gc.ca	Natural Resources Canada
Enric Mateu Serrats	emateu@cener.com	CENER
Fabienne Sallaberry	fsallaberry@cener.com	CENER
Francisco Fernandes	ffernandes@energie.pt	Energie
Graham Morrison	g.morrison@unsw.edu.au	University of New South Wales
Harald Drueck	drueck@itw.uni-stuttgart.de	ITW University of Stuttgart
Franz Helminger	franz.helminger@ait.ac.at	Austrian Institute of Technology
Heinrich Huber	heinrich.huber@ait.ac.at	Austrian Institute of Technology
Jim Huggins	huggins@fsec.ucf.edu	Florida Solar Energy Center/SRCC
Joakim Bystrom	info@lumicum.se	Lumicum
Joakim Byström	joakim@absolicon.com	Absolicon
Jordi Cadafalch	jordi.cadafalch@rdmes.com	RDMES
Josef Buchinger	josef.buchinger@arsenal.ac.at	Arsenal Research
Karsten Lampe	lampe@isfh.de	ISFH
Ken Guthrie	Ken.Guthrie@sustainability.vic.gov.au	Sustainability Victoria, Standards Austra-lia Committee
Korbinian Kramer	Korbinian.Kramer@ise.fraunhofer.de	Fraunhofer Institute, ISE
Jurken Kosok	juregen.kosok@de.bosch.com	Bosch
Lourdes Ramirez Santigosa	lramirez@cener.com	CENER
Manual Lopes Prates	lopes.prates@ineti.pt	INETI
Manuel Collares-Pereira	collares.pereira@ineti.pt	INETI
Maria Joao Carvalho	mjoao.carvalho@ineti.pt	INETI
Mark Thornbloom	ThoM@vitoteam.com	Kelelo Engineering
Markus Kratz	m.kratz@FZ-Juelich.de	Forschungszentrum Jülich - PTJ
Markus Peter	markus.peter@dp-quadrat.de	University of Oslo
Nele Rumler	rumler@isfh.de	Institut für Solarenergieforschung Hameln (ISFH)
Paolo Trisoglio	paolo.trisoglio@modulouno.it	Modulo Uno
Peter Kovacs	peter.kovacs@sp.se	SP Technical Research Institute of Swe-den
Pierluigi Premoli	Pierluigi.Premoli@icim.it	Institute of Industrial Certification for Mechanics ICIM

Pilar Navarro Rivero	privero@itccanarias.org	Canary Islands Institute of Technology
Richard Pelan	richard.pelan@kingspan - renewables.com	Kingspan Renewables
Robert Hassett	robert.hassett@ee.doe.gov	U.S. Department of Energy
Rodolphe Morlot	rodolphe.morlot@ademe.fr	Agence de l'Environnement et de la Maîtrise de l'Energie
Roland Sterrer	Roland.Sterrer@arsenal.ac.at	Austrian Institute of Technology
Sandy Klein	klein@engr.wisc.edu	Wisconsin State University
Sarah Miller	sarah.miller@csiro.au	Commonwealth Scientific and Industrial Research Organisation (CSIRO, Australia)
Stefan Albrecht	s.abrecht@slar-experience.de	Solar Experience
Stephan Fischer	fischer@itw.uni-stuttgart.de	ITW University of Stuttgart

Task 44

Solar and Heat Pump Systems

Jean-Christophe Hadorn
Base Consultants SA
Operating Agent for the Swiss Federal Office of Energy

TASK DESCRIPTION

The objective of this Task is to assess performances and relevance of combined systems using solar thermal and heat pumps, to provide a common definition of performances of such systems, and to contribute to successful market penetration of these new promising combinations of renewable technologies.

The scope of the Task considers solar thermal systems in combination with heat pumps, applied for the supply of domestic hot water and heating in family houses. It is thus dedicated to small systems in the range of 5 to 20 kW.

Any type of solar collector can be considered: using a liquid heat transfer fluid, air, hybrid collectors, or even hybrid thermal and photovoltaic or "PVT" collectors. All of them can be glazed or unglazed.

Any type of source of heat for the heat pump can be considered: air, water or ground source. The main focus will be on heat pumps driven by electricity, as the market is so oriented. However during the course of the Task it might be become relevant to consider thermally driven heat pumps since 100% solar could then be achieved.

To limit the scope, comfort cooling of buildings is not directly addressed in the Task common work, although it is not forbidden for a heat pump to be used for cooling purposes besides its main heating objective, for example in reverse mode.

The Task covers market available solutions as well as advanced solutions, which may be still in a laboratory stage or still will be developed during the course of the Task.

The Task is a joint effort of the Solar Heating and Cooling Programme and the Heat Pmp Programme. It is Task 44 for SHC and Annex 38 for HPP.

The Task is organized in the following Subtasks:

Subtask A: Solutions and Generic Systems
(Lead Country: Germany, Fraunhofer ISE, Sebastian Herkel)

The objective of Subtask A is to collect, create and disseminate information about the current and future solutions for combining solar thermal and heat pump to meet heat requirements of a one family house.

Subtask B: Performance Assessment
(Lead Country: Austria, AIT, Ivan Malenkovic)

The objective of this subtask is to reach a common definition on what are the figures of merits of solar + heat pump systems and how to assess them.This work can lead to prenormative definition on how to test and report the performance of a combined solar and heat pump system.

Subtask C: Modelling and Simulation
(Lead Country: Switzerland, SPF, Michel Haller)

The objective of subtask C is to provide modelling tools for all of the Task 44 generic solar and heat pump systems and to report sensitivity analysis on most of the systems such as being able to pinpoint important features and marginal ones in a given system configuration.
Sizing of systems will also be possible using the output of this Subtask, either with the computing tools developed or with general or system specific tables.

Subtask D: Dissemination and Market Support
(Lead Country: Italy, EURAC, Wolfram Sparber).

The objective of this subtask is to provide information to the external world of Task 44 during the course of the Task so that value added created by the participants can be transferred as fast as possible to a growing market. A second objective is to deliver the final book of Task 44 aimed as a reference document in the field of solar heat and heat pumps.

Main Deliverables

- Technical reports on existing and monitored systems
- Map of generic systems with pros and cons
- New set of performance indicators
- Procedure to test combined solar and heat pump systems
- Technical reports on systems tested in laboratory with this procedure
- New reference framework for simulating solar and heat pumps systems
- New components models or compiled existing ones
- Website with all major reports and papers
- Educational material on the website
- Support to national workshops about the topic "solar and heat pump"
- Papers at international conferences
- Newsletters along the Task duration
- Final handbook with all methods developped and results found

Duration

The Task started on 1 January 2010 and will end on 31 December 2013.

ACTIVITIES DURING 2010

- The Subtask C leader was changed from Chris Bales of Sweden to Michel Haller of Switzerland.
- The 1st and 2nd Task Experts meetings were held in Bolzano and Vienna.
- An industry/public workshop was held in conjunction with the Task Experts meeting in Italy, with 50 participants from local heating industry and authorities.
- Task participants presented at EUROSUN 2010 in Graz, Austria. Experts presented oral presentations and posters, including a Task poster at the SHC exhibition booth.

Results In 2010

Subtask A: Solutions and Generic Systems

Subtask A has been dealing in 2010 with some 20 different existing systems that are or will be monitored in the field. Prior to the discussion on existing projects, Subtask A has generates a number of generic designs of systems in order to establish a framework for a common classification.

Seven generic types have been identified.

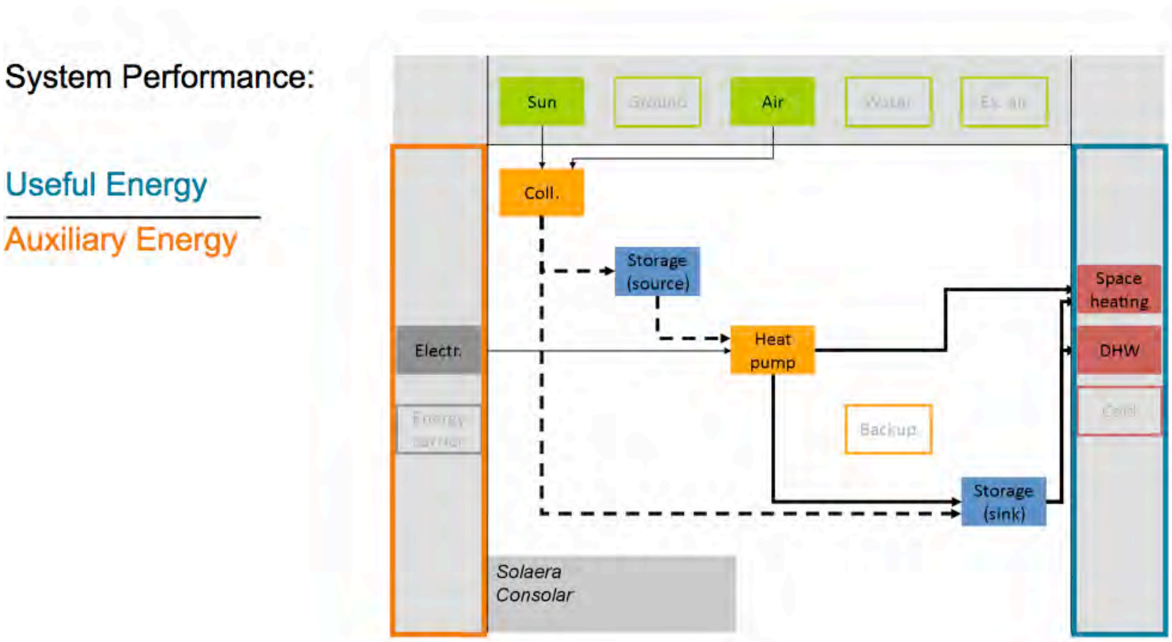


Figure 1. New "square layout" to describe a solar and heat pump combination.

More will probably be added as the work progresses.

A new way to describe a solar and heat pump configuration has been developed by Subtask A. Called the "square layout" it allows to understand at a glance the type of system the author is presenting. It has also other advantages in terms of depicting energy fluxes, location of meters and energy performance calculations. A companion description was derived with a letter convention so that the sources and the sinks in the system can be identified with ease.

Field test results for some 20 projects will be reported with a format that has been discussed during the year. Due to difficult financing, some might disappear. Most of the remaining projects will be monitored and reported during the Task duration and fit well with our scope and time frame. Some have already been measured and will be reported with the common tools of Subtask A and figures of merits developed in Subtask B. Some will be simulated with the tools of Subtask C. We would welcome more projects from outside Europe but no USA representatives unfortunately did attend Meeting 2.

Subtask B: Performance Assessment

The output of this Task should ideally be used by the industry to communicate the performances of the system they promote, like in the solar collector market collectors are reported with their efficiency curve which makes them comparable with others at least on one important criteria which is the energy performance. Laboratory testing of combined systems is also part of Subtask B.

Task 44 has gathered five laboratories form Austria, Germany, Italy, Spain, Switzerland to work on laboratory testing and definition of standards.
Subtask leader presented the latest information on the standardized definitions of performance figures for heat pump (COP, SCOP, SPF and others). Deciding on a common was not reached during 2010 due to the many different views and especially on the primary energy factors. More joint effort is required. Task 44 has established an official link to the EU project Quaist that deals with similar questions.
Common testing procedure was discussed and not yet fixed, for example the number of days of a representative sequence for a year (12 or more) is still an open question that need real testing and extrapolation.

Subtask C: Modelling and Simulation

During 2010, Subtask C worked to define a new simulation framework based on Task 32 framework. More parameters needed for solar and heat pump systems were presented by the Subtask leader. Discussion on representative climate stations took place. Some parameters need more work (ground properties in chosen climate locations for instance).
A change of Subtask leader during summer due to financing issues was necessary and we manage to find a very good expert, delaying not too much the progress of the subtask.
A survey of models for each component of a solar and heat pump systems was done.
The choice of the platform is also a controversial question. Several systems have been simulated with different packages (matlab/simulink or TRNSYS) but these were done for national or project purposes. It is not yet with the Task 44 package that is being developed under C1 and C2.
Working groups on components have been set up (collector modelling, ground modelling, heat pump dynamic modelling, storage models, boundary conditions, platform independence, etc..).

Subtask D: Dissemination and Market Support

During 2010, the website of the Task was developed within the iea-shc framework. At the beginning of the Task, it was foreseen to have another site hosted at Eurac the subtask leader. Since the iea-shc framework has been much enhanced, we decided in September 2010 to have everything on one site only. There is a public section and a work area with now several levels of rights (OA, subtask leaders and members).

Educational material will be put progressively on the web site. During the year, it was decided to have some 10 to 20 schematic of existing systems and their translation into the square framework developed within subtask A.
A professional under contract of EURAC designed several new logos in June 2010 and the management of the Task chose the final version in a ballot.

Several papers from Task 44 participants have been presented at Eurosun 2010 in Graz, using the new Task logo. A Task poster was done to be placed at SHC booth during Eurosun 2010.

A policy paper on the future of our technology asked by Exco have been sketched but not yet written.

The table of contents of the final Task handbook was discussed and agreed upon.

WORK PLANNED FOR 2011

Key activities planned for 2011 include:

- Two Subtask group meetings
- Activities as planned in each subtask
- Joint meeting with SHC Task 45 in Barcelona, Spain
- Industry workshop in Barcelona, Spain
- Meeting in Marseille, France in conjunction with ESTEC 2011
- Articles for conferences and publications
- Annual Task newsletter

LINKS WITH INDUSTRY

Several solar manufactures collaborate with university labs in our Task.
We also work in contact with the European Heat Pump Association (EHPA).

REPORTS PUBLISHED IN 2010

No reports were published. Articles were presented at OTTI (20. Symposium THERMISCHE SOLARENERGIE, May 5-7 2010, Bad Staffelstein, Germany) and, EUROSUN 2010 (Graz, Austria).

REPORTS PLANNED FOR 2011

Subtask A: Review of existing and new systems
Subtask B: Definition of performance indicators
Subtask C: Task 44 reference framework for simulation will be defined, publication in 2012
Subtask D: Task newsletter #1

MEETINGS IN 2010

1st Experts Meeting
April 29-30
Bolzano, Italy

2nd Experts Meeting
October 28-29
Vienna, Austria

MEETINGS PLANNED FOR 2011

3d Experts Meeting
April 7-8
Barcelona, Spain

4th Experts Meeting
October 18-19
Marseille, France
(In conjunction with ESTEC 2011)

SHC TASK 44/HPP ANNEX 38 NATIONAL CONTACTS

Operating Agent
Jean-Christophe Hadorn
BASE Consultants SA
8 rue du Nant
CH-1207 Geneva
Switzerland
Tel: + 41 22 840 20 80
jchadorn@baseconsultants.com

Subtask A Leader
Sebastian Herkel
Head of Solar Building Group
Dept. Thermal Systems and Buildings
Fraunhofer Institute for Solar Energy Systems
Heidenhofstrasse 2,
79110 Freiburg
Germany
Tel: +49 761 4588 5117
sebastian.herkel@ise.fraunhofer.de
www.ise.fraunhofer.de

Subtask B Leader
Ivan Malenkovic
Energy Department
Sustainable Thermal Energy Systems
AIT Austrian Institute of Technology
Österreichisches Forschungs und Prüfzentrum Arsenal Ges.m.b.H.
Giefinggasse 2
1210 Vienna
Austria
Tel: +43(0) 50550-6350
ivan.malenkovic@ait.ac.at
www.ait.ac.at

Subtask C Leader
Michel Haller
Institut für Solartechnik SPF
Hochschule für Technik Rapperswil HSR
Oberseestr. 10
CH-8640 Rapperswil
Switzerland
Tel: +41 55 222 48 36
michel.haller@solarenergy.ch
www.solarenergy.ch

Subtask D Leader
Wolfram Sparber
Institute for Renewable Energy
EURAC research
Viale Druso 1
I-39100 Bolzano
Italy
Tel: +39 0471 055 601
wolfram.sparber@eurac.edu
www.eurac.edu

NATIONAL EXPERTS & CONTACTS

The following is a list of National Experts & Contacts as identified as Participants of Task meetings or interested during 2010. Please go to the Task page on the SHC web site for updates: http://www.iea-shc.org/task44/index.html

Austria

Alexander Thür
AEE Intec - Institut für Nachhaltige Technologien

Ivan Malenkovic
AIT Vienna

Martin Hallegger
General Solar Systems GmbH

Andreas Heinz
Werner Lerch
Institut für Wärmetechnik TU Graz

Fabian Ochs
UNI Innsbruck

Belgium

Raf De Herdt
Filip Van der Schoor
De Nayer Instituut

Canada

Jeremy Sager
Natural Resources Canada

Denmark

Ole Balslev-Olesen
Cenergia Energy Consultants

Elsa Andersen
DTU

Klaus Ellehauge
Ellehauge & Kildemoes

Finland

Kai Sirén
Aalto University School of Science and Technology Department of Energy Technology

France

Radulescu Mihai
EDF R&D

Germany

Sebastian Herkel
Korbinian Kramer
Jörn Ruschenburg
Fraunhofer-Institut für Solare Energiesysteme ISE

Christian Stadler
General Solar Systems Deutschland GmbH

Christoph Trinkl
Hochschule Ingolstadt Institut für Angewandte Forschung

Erik Bertram
Antoine Dalibard
Institut für Solarenergieforschung Hameln/Emmerthal GmbH

Frank Thole
Schueco

Sebastian Bonk
Anja Loose
Universität Stuttgart Institut für Thermodynamik und Wärmetechnik (ITW)

Wolfgang Kramer
Wagner & Co. Solartechnik GmbH

Italy

Roberto Fedrizzi
Wolfram Sparber
EURAC

Osama Ayadi
Alberto Mauro
Lorenzo Pistocchini
Politechnico di Milano

Portugal

Jorge Facao
LNEG Lisbon

Spain
Òscar Càmara Moreno
Daniel González i Castellví
Aiguasol
Jorge Payá Herrero
Institute for Energy Engineering, Universidad Politécnica de Valencia

Dani Carbonell Sanchez
RDMES

Sweden
Elisabeth Kjellsson
Building Physics, Lund University

Bengt Perers
DTU DK & SERC Sweden

Hatef Madani
KTH

Ulrik Pettersson
SP Sveriges Tekniska Forskningsinstitut
SP Technical Research

Chris Bales
SREC, Borlange

Switzerland
Bernard Thissen

Energie Solaire SA
Jacques Bony
BUNEA Mircea
HEIG-VD

Peter Kurmann
Hochschule für Technik und Architektur Freiburg

Thomas Afjei
Ralf Dott
Institut Energie am Bau - FHNW

Elimar Frank
Michel Haller
SPF Institut für Solartechnik

United States
Tim Moss
SANDIA

Tim Merrigan
NREL

Les Nelson
Western Renewables Group

Members & Tasks

EXECUTIVE COMMITTEE MEMBERS - As of January 2011

AUSTRALIA
Mr. Max Maffucci
Standards Australia International
GPO Box 5420
Sydney, NSW 2001
max.maffucci@standards.org.au

Alternate
Mr. Ken Guthrie
Sustainability Victoria
Urban Workshop, Level 28
50 Lonsdale Street
Melbourne 3000
Ken.Guthrie@sustainability.vic.gov.au

AUSTRIA
Mr. Werner Weiss *(Chairman)*
AEE INTEC
Feldgasse 19
A-8200 Gleisdorf
w.weiss@aee.at

Alternate
Mrs. Sabine List
BMVIT
Renngasse 5
A-1010 Vienna
Tel: +43/1 71162 652919
Sabine.list@bmvit.gv.at

BELGIUM
Prof. André De Herde
Architecture et Climat
Université Catholique de Louvain
Place du Levant, 1
B-1348 Louvain-la-Neuve
deherde@arch.ucl.ac.be

CANADA
Mr. Doug McClenahan
CanmetENERGY
Natural Resources Canada
580 Booth Street
Ottawa, Ontario K1A 0E4
dmcclena@nrcan.gc.ca

DENMARK
Mr. Jens Windeleff
Danish Energy Agency
Amaliegade 44
DK-1256 Copenhagen K
jew@ens.dk

Alternate
Jan Erik Nielsen
PlanEnergi
Aggerupvej 1
DK-4330 Hvalsö
jen@solarkey.dk

EUROPEAN COMMISSION
Mr. Jose Riesgo
European Commission
Directorate C New & Renewable Sources
of Energy, Energy Efficiency & Innov.
Rue De Mot 24-3/ 152
B-1049 Brussels, BELGIUM
Jose.Riesgo@ec.europa.eu

FINLAND
Mr. Martti Korkiakoski
TEKES
P.O. Box 69
FIN-00101 Helsinki
Martti.Korkiakoski@tekes.fi

FRANCE
Ms. Céline Coulaud
ADEME - Centre de Sophia Antipolis
500 route des Lucioles
06560 VALBONNE
celine.coulaud@ademe.fr

GERMANY
Mr. Markus Kratz *(Vice Chair)*
Forschungszentrum Jülich GmbH
D-52425 Jülich
m.kratz@fz-juelich.de

Alternate
Dr. Peter Donat
Forschungszentrum Jülich GmbH
Zimmerstraße 26-27
10969 Berlin
p.donat@fz-juelich.de

ITALY
Mr. Michele Zinzi
ENEA UTEE-ERT s.p. 104
via Anguillarese, 301
00123 Rome
michele.zinzi@enea.it

MEXICO
Dr. Wilfrido Rivera Gomez-Franco
Center for Energy Research
National University of Mexico
Apdo. Postal #34
62580 Temixco, Morelos
wrgf@cie.unam.mx

Alternate
Dr. Camilo Arancibia Bulnes
Same address as above
caab@cie.unam.mx

NETHERLANDS
Mr. Lex Bosselaar
NL Agency
P.O. Box 8242
3503 RE Utrecht
L.Bosselaar@agentschapnl.nl

NEW ZEALAND
Mr. Michael Donn
School of Architecture
Victoria University of Wellington
P.O. Box 600
Wellington 1
michael.donn@vuw.ac.nz

NORWAY
Dr. Anne Gunnarshaug Lien
SINTEF Building and Infrastructure
Alferd Getz v3
NO-7465Trondheim
anne.g.lien@sintef.no

Alternate
Mr. Fritjof Salvesen
Asplan Viak AS
P.O. Box 24
1300 Sandvika
fritjof.salvesen@asplanviak.no

PORTUGAL
Mr. João A. Farinha Mendes *(Vice Chair)*
INETI – Edificio H
Departamento de Energias
Renovaveis
Estrada do Paco do Lumiar, 22
1649-038 Lisboa
farinha.mendes@ineti.pt

SINGAPORE
Mr. Kian Seng ANG
Building and Construction Authority
Director, Research
200 Braddell Road, ZEB Level 3
579700
ang_kian_seng@bca.gov.sg

SOUTH AFRICA
Dr. Thembakazi Mali
Senior Manager: Clean Energy Solutions
SANERI
P.O. Box 786141
Sandton, 2146
thembakazim@saneri.org.za

Alternate
Prof. Ernst Uken
Head: CPUT Energy Institute
P.O. Box 652
8000 Cape Town
ukene@cput.ac.za

SPAIN
Dr. María José Jiménez Taboada
Renewable Energy Division
CIEMAT
Carretera de Senés s/n
E-04200 Tabernas (Almeria)
mjose.jimenez@psa.es

Alternate
Mr. Enríquez Miranda
Renewable Energy Division
CIEMAT
Avenida Complutense 22
E-28040 Madrid
ricardo.enriquez@ciemat.es

SWEDEN
Dr. Jörgen Sjödin
Swedish Energy Agency
Energy Technology Department
Box 310
SE-631 04 Eskilstuna
jorgen.sjodin@swedishenergyagency.se

Alternate
Ms. Anita Larsson
Same address as above
Anita.larsson@swedishenergyagency.seM

SWITZERLAND
Mr. Andreas Eckmanns
Federal Office of Energy
CH-3003 Bern
andreas.eckmanns@bfe.admin.ch

Alternate
Mr. Urs Wolfer
Same address as above
urs.wolfer@bfe.admin.ch

UNITED STATES
Mr. Robert Hassett
U.S. Department of Energy
Solar Energy Technologies (EE-2J)
Office of Energy Efficiency and
Renewable Energy
1000 Independence Ave. S.W.
Washington, D.C. 20585-0121
robert.hassett@ee.doe.gov

Alternate
Tim Merrigan
National Renewable Energy Laboratory
1617 Cole Blvd, M/S 5202
Golden, CO 80401
tim.merrigan@nrel.gov

Kevin Degroat
Antares Group, Incorporated
4351 Garden City Drive, Suite 301
Landover, MD 20785, USA
kdegroat@antares.org

TASK OPERATING AGENTS

SOLAR RESOURCE KNOWLEDGE MANAGEMENT
Dr. Dave Renné
National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, Colorado 80401-3393
UNITED STATES
david_renne@nrel.gov

ADVANCED HOUSING RENOVATION WITH SOLAR & CONSERVATION
Mr. Fritjof Salvesen
KanEnergi AS
Hoffsveien 13
0275 Oslo
NORWAY
fs@kanenergi.no

SOLAR AIR-CONDITIONING & REFRIGERATION
Dr. Hans-Martin Henning
Fraunhofer Institute for Solar Energy Systems
Dept. of Thermal Systems and Buildings
Heidenhofstr. 2
D-79110 Freiburg
GERMANY
hans-martin.henning@ise.fraunhofer.de

POLYMERIC MATERIALS FOR SOLAR APPLICATIONS
Mr. Michael Köhl
Fraunhofer Institute for Solar Energy Systems
Heidenhofstr. 2
D-79 110 Freiburg
GERMANY
michael.koehl@ise.fraunhofer.de

NET ZERO ENERGY SOLAR BUILDINGS
Mr. Josef Ayoub
CanmetENERGY
Natural Resources Canada
1615, boul. Lionel-Boulet Varennes
Quebec J3X 1S6
CANADA
Josef.Ayoub@rncan-nrcan.gc.ca

SOLAR ENERGY AND ARCHITECTURE
Ms. Maria Wall
Dept. of Architecture and Built Environment
P.O. Box 118
SE-221 00 Lund
SWEDEN
maria.wall@ebd.lth.se

COMPACT THERMAL ENERGY STORAGE
Mr. Wim van Helden
ECN Energy Research Centre of the Netherlands
P.O. Box 1
NL 1755 ZG Petten
NETHERLANDS
vanhelden@ecn.nl

RATING AND CERTIFICATION PROCEDURES
Operating Agents
Les Nelson
Western Renewables Group
lnelson@westernrenewables.com

Jan Erik Nielsen
PlanEnergi
Aggerupvej 1
DK-4330 Hvalsö, DENMARK
jen@solarkey.dk

Project Manager
Mr. Kevin DeGroat
Antares Group, Incorporated
4351 Garden City Drive, Suite 301
Landover, MD 20785, USA
Tel: +1/301 789 7768
Fax: +1/301 731 1904
kdegroat@antares.org

SOLAR AND HEAT PUMP SYSTEMS
Mr. Jean-Christophe Hadorn
BASE CONSULTANTS SA
8 rue du Nant Josef.Ayoub@rncan-nrc
CH-1211 Geneva, SWITZERLAND
jchadorn@baseconsultants.com

LARGE SOLAR HEATING & COOLING SYSTEMS

Jan Erik Nielsen
PlanEnergi – Zealand Department
Aggerupvej 1
DK-4330 Hvalsoe, DENMARK
jen@solarkey.dk

***PROPOSED TASK* – SOLAR COOLING QUALITY ASSURANCE**

Daniel Mugnier
TECSOL SA.
105 av Alfred Kastler - BP 90434
66 004 Perpigan Cedex, FRANCE
daniel.mugnier@tecsol.fr

***PROPOSED TASK* - UTILITY SOLAR HEATING AND COOLING PROGRAMMES INFORMATION SHARING & DEVELOPMENT**

Chip Bircher
USH2O Coordinator
UNITED STATES
ush2o.mail@gmail.com

***PROPOSED TASK* - SOLAR HEAT INTEGRATION IN INDUSTRIAL PROCESSES**

Christoph Brunner
AEE INTEC
Feldgasse 19
A-8200 Gleisdorf, AUSTRIA
c.brunner@aee.at

IEA SECRETARIAT LIAISON

Mr. Takasune Ito
International Energy Agency
9 rue de la Fédération
75739 Paris Cedex 15
FRANCE
takatsune.ito@iea.org

SHC SECRETARIAT

Ms. Pamela Murphy
9131 S. Lake Shore Dr.
Cedar, MI 49621
UNITED STATES
pmurphy@KMGrp.net

WEB SUPPORT

Randy Martin
6851 Spanish Bay Drive
Windsor, CO 80550
UNITED STATES
randy@rlmartin.com

SHC PROJECTS & LEAD COUNTRIES

Task 1	Performance of Solar Heating and Cooling Systems, 1977-83 (Denmark)
Task 2	National Solar R & D Programs & Projects, 1977-84 (Japan)
Task 3	Solar Collector and System Testing, 1977-87 (Germany and United Kingdom)
Task 4	Insolation Handbook and Instrumentation Package, 1977-80 (United States)
Task 5	Existing Meteorological Information for Solar Applications, 1977-82 (Sweden)
Task 6	Evacuated Tubular Collector Performance, 1979-87 (United States)
Task 7	Central Solar Heating Plants with Seasonal Storage, 1979-89 (Sweden)
Task 8	Passive Solar Low Energy Homes, 1982-89 (United States)
Task 9	Solar Radiation and Pyranometry, 1982-91 (Canada and Germany)
Task 10	Solar Materials R & D, 1985-91 (Japan)
Task 11	Passive Solar Commercial Buildings, 1986-91 (Switzerland)
Task 12	Solar Building Analysis Tools, 1989-94 (United States)
Task 13	Advanced Solar Low Energy Buildings, 1989-94 (Norway)
Task 14	Advanced Active Solar Systems, 1990-94 (Canada)
Task 15	Advanced Central Solar Heating Plants, not initiated
Task 16	Photovoltaics for Buildings, 1990-95 (Germany)
Task 17	Measuring and Modeling Spectral Radiation, 1991-94 (Germany)
Task 18	Advanced Glazing Materials, 1991-97 (United Kingdom)
Task 19	Solar Air Systems, 1993-99 (Switzerland)
Task 20	Solar Energy in Building Renovation, 1993-98 (Sweden)
Task 21	Daylight in Buildings, 1995-99 (Denmark)
Task 22	Building Energy Analysis Tools, 1996-00 (United States)
Task 23	Optimization of Solar Energy Use in Large Buildings, 1997-02 (Norway)
Task 24	Solar Procurement, 1998-03 (Sweden)
Task 25	Solar Assisted Air Conditioning of Buildings, 1999-04 (Germany)
Task 26	Solar Combisystems, 1998-02 (Austria)
Task 27	Performance of Solar Facade Components, 2000-05 (Germany)
Task 28	Solar Sustainable Housing, 2000-05 (Switzerland)
Task 29	Solar Crop Drying, 2000-06 (Canada)
Task 30	Solar Cities, not initiated
Task 31	Daylighting Buildings in the 21st Century, 2001-05 (Australia)
Task 32	Advanced Storage Concepts for Solar and Low Energy Buildings, 2003-07 (Switzerland)
Task 33	Solar Heat for Industrial Processes, 2003-07 (Austria)
Task 34	Testing and Validation of Building Energy Simulation Tools, 2003-07 (United States)
Task 35	PV/Thermal Systems, 2005-07 (Denmark)
Task 36	Solar Resource Knowledge Management, 2005-11 (United States)
Task 37	Advanced Housing Renovation with Solar & Conservation, 2006-09 (Norway)
Task 38	Solar Air Conditioning and Refrigeration, 2006-10 (Germany)
Task 39	Polymeric Materials for Solar Thermal Applications, 2006-14 (Germany)
Task 40	Towards Net Zero Energy Solar Buildings, 2008-13 (Canada)
Task 41	Solar Energy and Architecture, 2009-12 (Denmark, Norway, Sweden)
Task 42	Compact Thermal Energy Storage, 2009-12 (Netherlands)
Task 43	Rating and Certification Procedures – Advanced Solar Thermal Testing and Characterization for Certification of Collectors and Systems, 2009-12 (United States & Denmark)
Task 44	Solar and Heat Pump Systems, 2010-13 (Switzerland)
Task 45	Large Solar Heating & Cooling Systems, 2011-13 (Denmark)
Task 46	Solar Resource Assessment and Forecasting, 2011-15 (United States)
Task 47	Renovation in Non-residential Buildings, 2011-14 (Norway)

IEA SOLAR HEATING & COOLING PROGRAMME

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